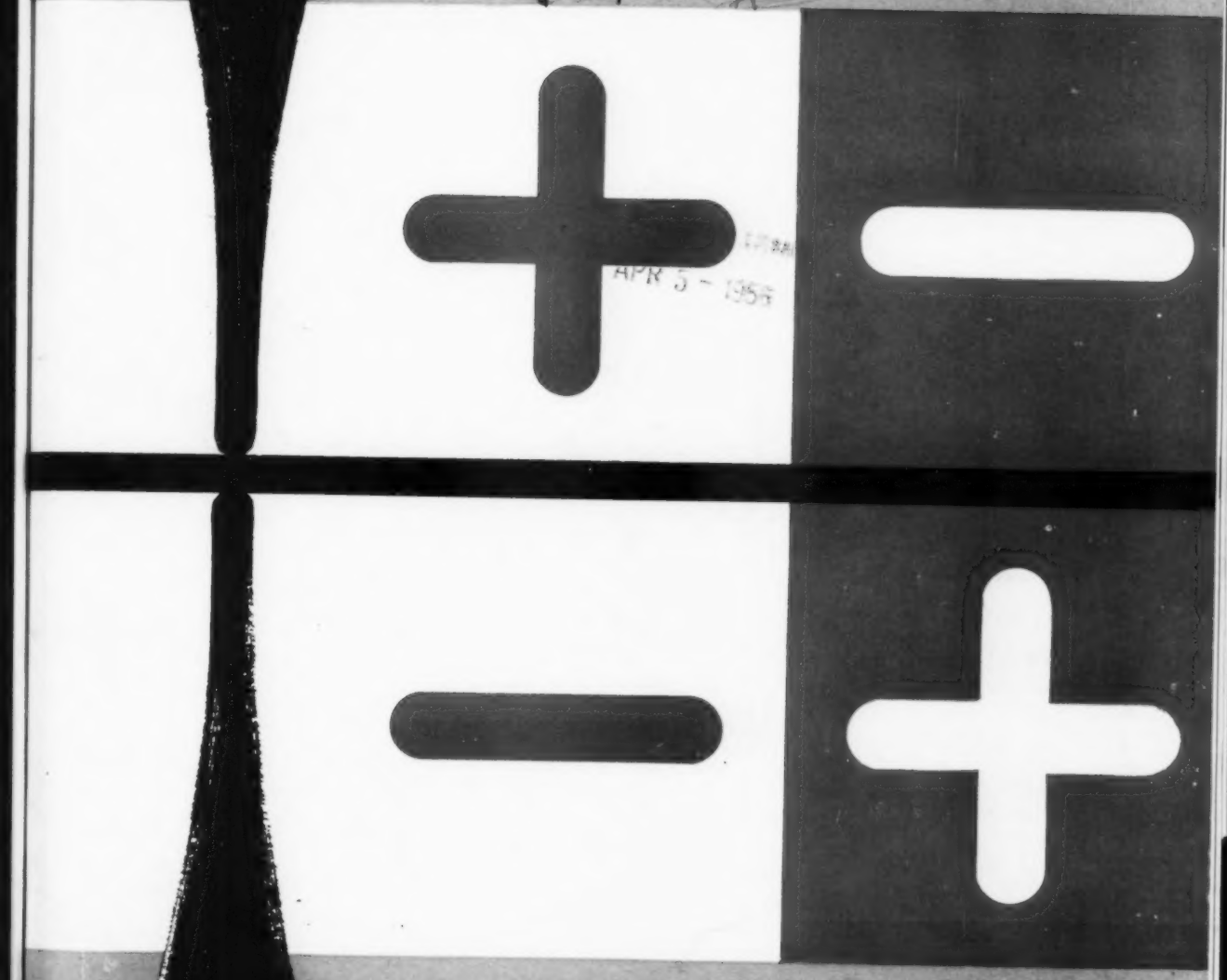
APRIL 5, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Dimension Control

Contents, page 3

Install it... then Forget it!

The

NORMA-HOFFMANN

"CARTRIDGE"

BEARING

•

Needs No Attention

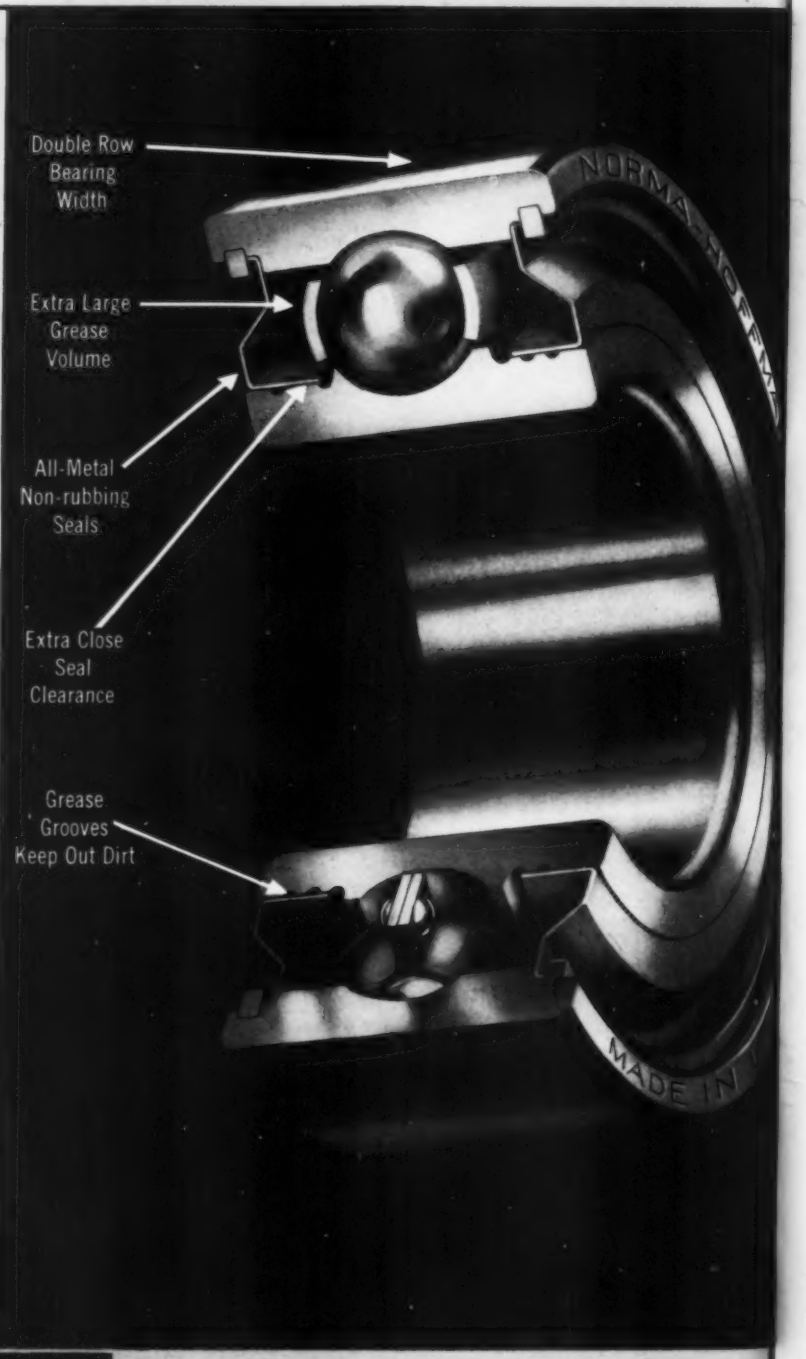
"Cartridge" ball bearings installed more than 15 years are still running without relubrication.

Here's Why:

"Cartridge" double row width bearings are complete units — ready for installation.

"Cartridge" bearings are adequately lubricated — with correct amount and the right kind of grease.

"Cartridge" bearings are fully protected — with highly efficient all-metal, non-rubbing lifetime seals.



NORMA-HOFFMANN *Precision* **BEARINGS**

BALL • ROLLER • THRUST

NORMA-HOFFMANN BEARINGS CORPORATION

STAMFORD, CONNECTICUT

FOUNDED IN 1911

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Introducing the COMET

An Advanced Conception of Valving by Ross!

- Direct solenoid operated, balanced spool 4-Way—for air or oil service.
- Engineered and built to tolerances of .0001".
- Conforms to JIC standards.
- Complete valve cycle within 0.033 sec.
- Made of aluminum—single solenoid, base mounted weighs only 3½ lbs.
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- Small and compact—7¼" by 3½" by 3⅞". ¼" diameter flow capacity.
- Available with ¼" or ⅜" pipe tap for inline, manifold or base mounted; single solenoid spring return, double solenoid momentary; double solenoid three position.

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Ross OPERATING VALVE COMPANY

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How to put on Pressure in the Clutch

FREQUENT trouble spots on oil rigs are the friction clutches in the power units. Service life can range as low as several weeks. Valuable drilling equipment can be tied up and down-time costs can amount to thousands of dollars.

Heart of the trouble on one type of clutch was its air tube. Inflation or deflation of this tube actuated the clutch by engaging or disengaging the opposing friction plates. But the oil and constant flexing resulted in tube failure. Finally, the G.T.M.—Goodyear Technical Man—was consulted.

The G.T.M., in cooperation with the rig manufacturer, changed the design, the rubber compound and the molding technique. The result was a tube which, on one particular rig where previous service averaged two to five months, has served 20 months and is still going strong. Laboratory tests of this new tube show an expected life of over ten years.

How can the G.T.M. improve your product? All molded goods problems find better solutions at Goodyear, Industrial Products Division, St. Marys, Ohio or Akron 16, Ohio.

MOLDED GOODS by

GOODYEAR

THE GREATEST NAME IN RUBBER

We think you'll like "THE GREATEST STORY EVER TOLD"—every Sunday—ABC Radio Network—THE GOODYEAR TELEVISION PLAYHOUSE—every other Sunday—NBC TV Network

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

April 5, 1956
Volume 28—No. 7

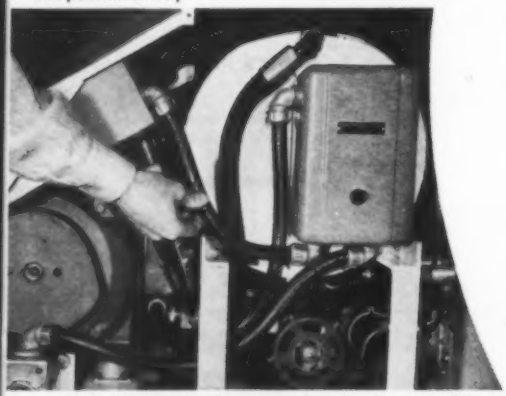
REGULAR DEPARTMENTS

Machine Design is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations performing design engineering of products are also eligible.

Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $20. Accepted as Controlled Circulation publication at Cleveland, Ohio.

On Machine Tool—Extra flexible type E.F. is readily installed, withstands flexing, protects against oil, stays tight, leakproof.

Parking Lot Control Gate—⅜" I.D. type U.A. makes easy U-bend, protects wiring against moisture and possible oil drip.



In Fluid Test Machine—Three lengths of ½" type E.F. Sealtite prove easy to handle, permit neat, fast installation without need for special tools. Test equipment manufactured by the Pacific Airmotive Corporation, Linden, New Jersey.

FLEXIBLE—
for faster installation!
LIQUID-TIGHT—
for long life! . . . It's SEALTITE

These three installations demonstrate how Sealtite* liquid-tight flexible conduit (1) protects wiring under severe operating conditions, and (2) pays its way by saving installation time.

Sealtite is the *original* liquid-tight flexible conduit—met Joint Industry Conference (J.I.C.) Requirements in 1945. Wherever vibration, motion, constant flexing, wet or corrosive operating conditions or space limitations pose a tough conduit problem, it pays to use Sealtite. Installed in far less time than it takes to bend and fit rigid conduit, its tough extruded polyvinyl outer jacket keeps out moisture, oil, chemicals, the elements. Core of Flexible Galvanized Steel withstands severe mechanical stress.

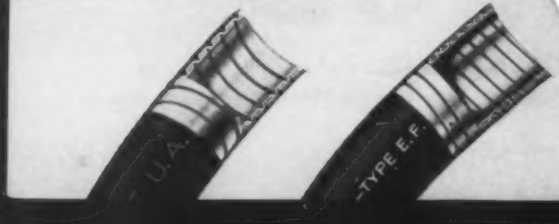
*Trade Mark

5518

ELECTRICAL WHOLESALERS stock both types in easy-to-handle coils. Buy it in long random lengths . . . cut on the job without waste. Ask also for liquid-tight connectors from stock. For detailed information, write for Sealtite bulletins. Address: *The American Brass Company, American Metal Hose Division, Waterbury 20, Conn.*

SEALTITE *flexible, liquid-tight conduit*

AN **ANACONDA**® PRODUCT



TYPE U.A. is approved by Underwriters' Laboratories for service in wet spots. Copper conductor wound spirally inside conduit for positive ground. Jacket in black or light gray.

TYPE E.F. is extra flexible. Ideal for machine tool applications. Meets J.I.C. requirements. Now available from mill stocks in black, and in machine tool standard light gray at no extra cost.

Engineering News Roundup

Program Announced for Third Mechanisms Conference

Panel Discussions to Round Out Five Talks

CLEVELAND, O.—Basic program of the Third Conference on Mechanisms has been announced.

The program features papers by both university and industry experts and a series of discussion sessions headed by panels of both university and industry men. The Conference is cosponsored by the School of Mechanical Engineering, Purdue University, and MACHINE DESIGN. It will be held on the Purdue campus, West Lafayette, Ind., on May 24 and 25.

The first paper on May 24 will feature mechanism synthesis—systematic procedures for mechanism selection and design. Viewpoints on synthesis, an often misunderstood subject, are undergoing change in this country and abroad. Professor Richard S. Hartenberg of Northwestern University will clarify the present status of mechanism synthesis and point out its practical applications.

Mechanisms for intermittent motion will be the principal theme of the afternoon session on May 24. Professor F. J. Bogardus of Purdue will present a comprehensive survey of intermittent-motion mechanisms. Practical design and manufacturing factors for starwheels, one of the many intermittent-motion mechanisms, will be discussed by Karl Kist of Harris-Seybold Co., Cleveland.

The afternoon session will conclude with two simultaneous discussion-group sessions: (1) intermittent-motion mechanisms and (2) how to select mechanisms. Questions and problems, to be handled by panels, are invited—both before and during the session.

Cam design will be the feature of the morning session on May 25. Professor Harold A. Rothbart of City College of New York will discuss basic factors in cam design, giving an integrated view of all design factors and their relationships. W. D. Cram of United Shoe Machinery Corp., Beverly, Mass., will deal with a variety of specific cam factors, such as overlapping of motions, accuracy and method of manufacture and loading between cam and follower.

A panel discussion session on cams and cam problems will follow. Simultaneously, a work-shop session will be held on dimensional problems in mechanism design and manufacture.

The final afternoon, May 25, will

LARGEST COMBINATION TANKER AND ORE CARRIER, the *Petrolore* is the first ship of major size built to carry both liquid and dry bulk cargoes. She is self-unloading with respect to both oil and ore. The *Petrolore* is 789 ft long; driven by 12,500-hp turbine engines; travels at an average speed of 15 knots. Cargo capacity is 403,000 barrels of oil or 67,300 tons of ore. Ore is removed by a 485-ft long, 60-ft wide conveyor belt. All of the ship's 65 cargo holds are filled with petroleum; ore is carried in the 26 center holds

←Facing Page—ITEM 556

be devoted to a variety of discussion groups organized according to industry interests. The aim of these sessions is to provide opportunity for designers and engineers of similar machine or product types to exchange discussion on common interests and problems.

Highlights of the program are a banquet on May 24 and a luncheon on May 25. An informal but pertinent program will follow the banquet.

Registration fee for the Conference is $20.00 which will include banquet, luncheon, and transactions. Rooms will be available at the Memorial Union on the Purdue Campus as well as at hotels and motels in Lafayette. Registration, travel, and housing details will appear in the next issue of MACHINE DESIGN.

TEXAS-TYPE MONORAIL system is currently under construction and test in Houston. The car, 55 ft long, 7 ft wide, is made of glass fabric and suspended below a 30-in. pipe. Named Skyway, the monorail is powered by a 305-hp engine. Eight pneumatic tires run on the tube and 16 rubber guide wheels hold the car in place. In case of tire blowout, the unit runs on auxiliary steel wheels. Claimed operating speed is 60 mph

New Electronic Computer Is High-Speed Accountant

NEWTON HIGHLANDS, MASS. — A new electronic computer tailored to the needs of business has been announced by Datamatic Corp. The system is called "Datamatic 1000" and employs high-speed computer principles for business record-keeping and accounting.

Original data is fed to the new system in the form of punched cards. A special transcription device translates, edits and transcribes the data onto 3-inch wide magnetic tapes at the rate of 900 cards per minute. One reel of tape, 2700 ft long, can store over 37 million decimal digits of information, the equivalent of the data on 465,000 punched cards.

Central tape unit of Datamatic 1000 stores condensed business records and accounts as magnetic impressions on 3-in. tape, 2700 ft long

The central unit of the system operates at the rate of 60,000 digits per second. Simultaneously it performs 1000 multiplications, 4000 additions or 5000 comparisons.

Arrangement of the system permits the incorporation of as many as 100 tape units, any one of which can be referred to without disturbing the others.

Reports from the tape files can

Front Cover

Control of dimensions and tolerances is a highly important facet of design, particularly on precision units. It can also be a serious design problem. Earlwood T. Fortini's series of articles starting in this issue provide a complete kit of tools for assigning tolerances and, incidentally, a very striking theme for artist George Farnsworth's cover.

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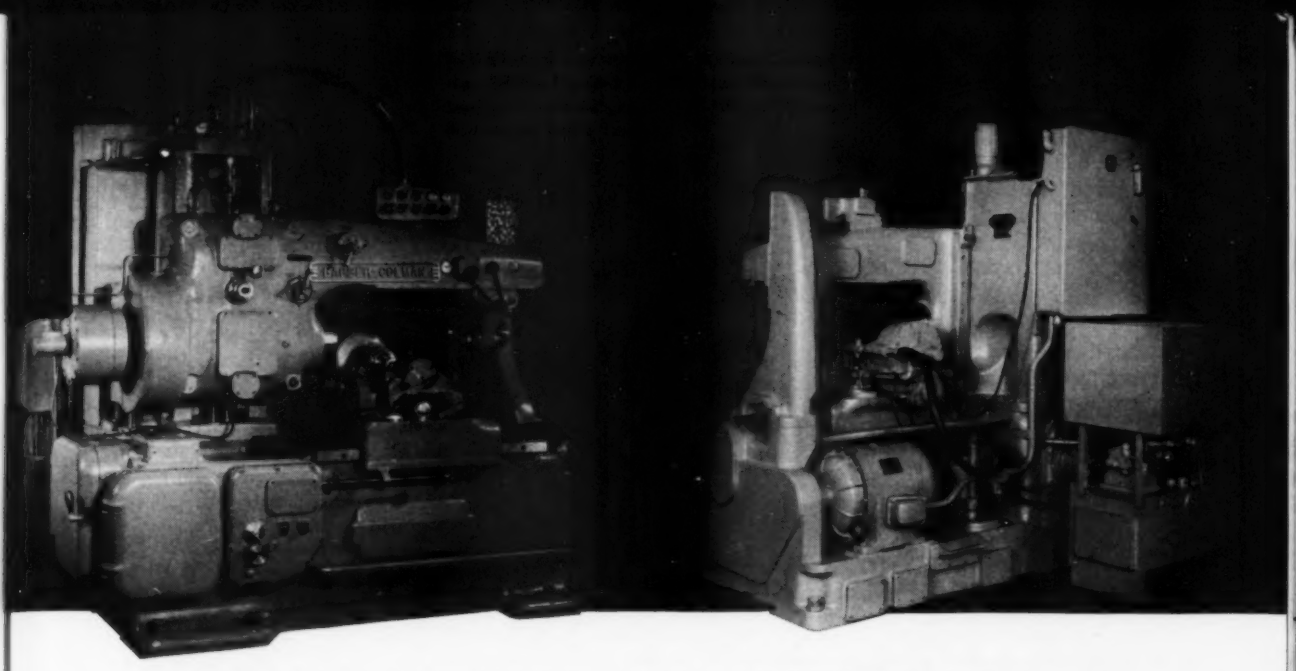
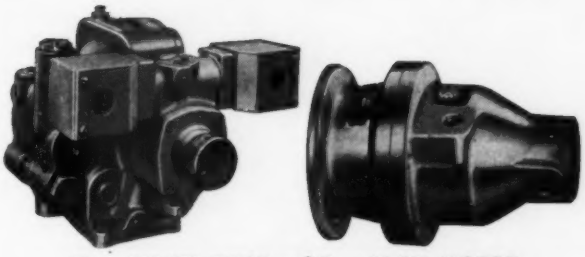


ANOTHER TRIUMPH IN MACHINE DESIGN THAT USES OILGEAR "ANY-SPEED" DRIVE FEEDS

Barber-Colman's new high-speed hobbing machine may be totally different from the machines you build. But the machine design problems they encountered in developing this machine could very well be your problems. Among the problems encountered was that of feed. To solve this problem, Barber-Colman selected Oilgear Fluid Power Feeds. These feeds give them the infinitely variable output to provide a hobbing feed range of .020″ to 1″ per minute. In addition, they provide a far more constant hobbing feed despite changes in load or system temperatures. They also provide cushioned, positive, precise, fast-acting electro-hydraulic control of feed, rapid traverse, and stop through automatic switches. Finally, they provide power for operating ten auxiliary cylinders and three valves. One Oilgear type AX-311 Pump supplies fluid power for the entire machine.

You have much to gain if you stop a moment and ask: "Why are leading machine and machine tool builders turning to Oilgear? Am *I* missing an opportunity to improve machine performance?" Why don't you compare your machine needs with what Oilgear "ANY-SPEED" Drives and Feeds can provide? You can rest assured that we will recommend our product only when it is to your advantage. Tell us your needs. We'll give you a specific appraisal of the possibilities. Write now. THE OILGEAR COMPANY, 1568 W. Pierce Street, Milwaukee 4, Wisconsin.



Type AX-311 PUMP and Type H-311 MOTOR
OILGEAR "ANY-SPEED" DRIVE FEED

OILGEAR
Fluid Power

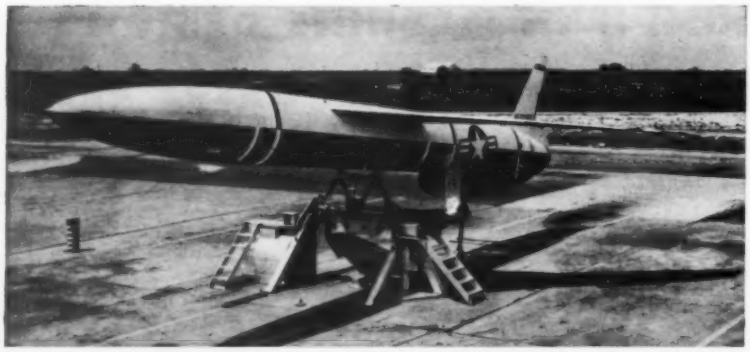
PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS & VALVES

be turned out at the rate of 6000 punched cards per hour or 900 printed lines per minute. A complete system installed will cover between 5000 and 18,000 sq ft of floor space.

Overheated bearings are detected and warning signals actuated by this miniature thermostat within 4 seconds from the time the overheat condition occurs. The control does not require an amplifier, relays, or bridge pickup box.

The thermostat tube is nested in Silastic rubber cement injected into a Teflon sleeve. The housing is steel. The aluminum temperature-sensing tip can be compressed 1/32-in. to ensure a positive contact with the motor bearing. The 1-ounce Thermal Switch is a product of Vapor Heating Co.



INTERCONTINENTAL "SNARK" is this guided missile, the first unveiled by U. S. Air Force. The pilotless bomber is capable of delivering an atomic warhead over trans-oceanic distances. Snark was made by Northrop Aircraft, is currently under test at Patrick Air Force Base, Florida

Busy Designers Will Find Philly Show a Time-Saver

Industries and ASME Plan Concentrated Presentations

PHILADELPHIA—The Design Engineering Show and Conference scheduled here in Convention Hall from May 14 to 17 should have a natural appeal to the country's design engineers. It will save them a lot of time.

Equipment manufacturers and the ASME are making special efforts to present material of immediate concern and usefulness to designers. All this activity will be coordinated and concentrated in the four days the show is open. This will be the first occasion these related interests have teamed up on such a scale to help designers improve themselves and to serve their companies better.

Commenting on this aspect of the coming show, Robert M. Conklin, chief of the mechanical engineering division, Battelle Memorial Institute, and chairman of the ASME Machine Design division, said:

"Each new development in automatic, high-speed production equipment presents scores of design problems. As design engineering improves, the public is benefited by new products, better products and less expensive products. We hope to stimulate industrial thinking and planning for better design engineering by this national conference on the subject."

Advance registration cards for

Topics

Helicopter make-it-yourself kit will soon be available. Powered by a two-cycle 40-hp engine, the one-man machine weighs 360 lb and has a top speed of 60 mph. Price of the kit has not yet been announced.

• • •

Analog computer kit, another do-it-yourself project, is being marketed by the makers of Heathkits. It costs $700 and is supposed to be equivalent to a completed unit selling for over $100,000. It's not a toy or gadget (at that price!) and may be just the ticket for a budget-minded engineering outfit.

• • •

Mobilgas Economy Run for foreign cars will be held in April over a 1100 mile stretch starting in Capetown, South Africa. About 25 cars are entered in the event.

• • •

1957 autos may be introduced earlier this year. Some auto makers plan to jump the gun by having 57's ready August 1st. Slow sales of 1956 models are blamed.

• • •

Delayed hearing in one ear makes for better understanding of speech, according to a recent study. So a manufacturer of a telephone headset has incorporated a delay of a few milliseconds in one earpiece. It's said to produce a "live" effect.

• • •

Two radio-telescopes, one in Australia, the other at Ohio State University in Columbus, O. are to be built. Both will be used to receive radio emanations from the sky. Astronomers call these radio stars, not to be confused with TV stars of the human variety.

• • •

Viscount turboprop airliners will be delivered to U. S. airlines in ever increasing numbers. Vickers-Armstrong Ltd. plans to deliver 72 more this year and about 150 in 1957.

• • •

Auto export statistics show Great Britain first in 1955, with Western Germany second. U. S. exported the third largest number of cars.

• • •

Atomic submarine will be built by the British. They're also considering nuclear power plants for both merchant and naval ships.

Facing Page—ITEM 558→

the show may be obtained from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y. Information concerning the conference may be obtained either from the ASME or Clapp & Poliak.

Fluorescent Lamp Has Built-In Reflector

SALEM, MASS.—A new fluorescent lamp with an internal reflector surface has been announced by Sylvania Electric Products Inc. The new product is said to be the first American fluorescent lamp with directional light distribution.

An important application of the new lamp is in installations where dust or dirt are present. Increased lumen-hours are claimed because the lamp is relatively unaffected by deposits of opaque dust and dirt on its top surface.

The new lamp may be mounted bare without external reflectors. It can also be used in show cases and similar concealed lighting applications where space limitations make a reflector impractical. Indirect lighting effects may also be obtained by pointing the lamps towards the ceiling.

The Sylvania internal reflector covers more than half of the lamp's circumference. Initially, the new lamps are available in 4 and 8-ft single-pin types. Sylvania says they will be available in other sizes later.

NEW MEMBER OF A FAST FAMILY is this Super Sabre F-100D. This D-model of the USAF first fighter-bomber flys faster than sound and carries an autopilot, the first developed particularly for a supersonic jet. F-100D is 47 ft long, has 45-degree swept wings with a span of 38 ft.

MECHANICAL ELEPHANT is LeTourneau Electric Log Stacker. Forks 10 ft long and powered tusks handle a truck load all at once. The Stacker has handled loads of 28 tons, more than 5000 bd ft, 8 ft wide and 9 ft high. Electric motors for all the Stacker's movements are controlled by switches in the cab and powered by diesel generator at rear of machine

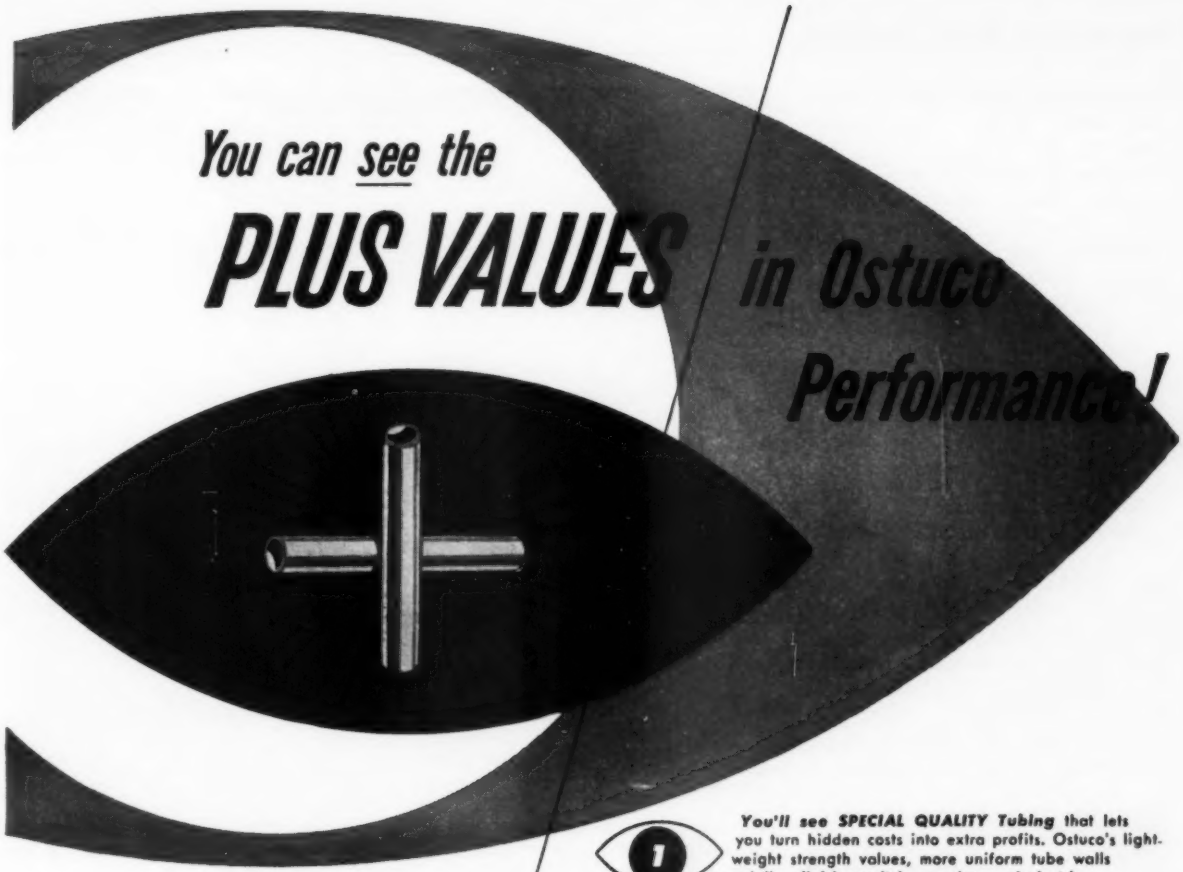
Human Engineering Institute To Be Held in June

STAMFORD, CONN.—Human engineering will be the subject of a five-day course of study sponsored by Dunlap and Associates Inc. in Stamford, June 18-22. This fourth annual Human Engineering Institute will be an advanced course based on new concepts in the design of equipment, consumer products and work places. Emphasis will be placed on the "systems approach" to design planning, allocation of functions between men and equipment, converting design specifications into products, and man-machine relationships as affected by automation. Problem-oriented small group discussions will be held.

Further information on the Institute can be obtained from Dr. Leon L. Thomas, Director, Human Engineering Institute, Dunlap and Associates Inc., 429 Atlantic St., Stamford, Conn.

Dropping and firing bombs into water currently occupies three Worcester Polytechnic Institute engineers at the Alden Hydraulic Laboratory. The work is part of a Navy research program to develop a projectile that is accurate and stable in its performance under all conditions. The bombs are miniature models. The experiments determine the behavior of

You can see the PLUS VALUES in Ostuco Performance!



1 ***You'll see SPECIAL QUALITY Tubing*** that lets you turn hidden costs into extra profits. Ostuco's light-weight strength values, more uniform tube walls and fine finish result in seamless and electric resistance welded steel tubing of unmatched quality.

2 ***You'll see DESIGN-ENGINEERING SERVICE*** go to work on your tubing problems. A wealth of design and production information is at your service. Ostuco's experience dates from the beginning of the seamless tube industry.

3 ***You'll see ON-TIME DELIVERY*** of tubing as promised! No costly delays that hold up your production. Ostuco has the reputation of making deliveries on schedule.

4 ***You'll see "SINGLE-SOURCE" SERVICE*** in action and you benefit through convenient, error-free handling of the entire order! Manufacturing and fabrication is under one roof at Ostuco—one order eliminates multiple shipments, saves time and handling costs.

Some good things our customers are saying about OSTUCO:

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"Your Mill is doing an excellent job with regard to maintaining delivery promises."

Hydraulic Equipment:
"We feel partial to you because of the excellent service."

Machine Tools:
"You are receiving 100% of the tubing we purchase and will continue to do so as long as you keep up the good quality and service."

Drilling Equipment:
"Your tubing is the best we've ever had because of its exceptional straightness and good workmanship."

Blue chip companies, the world over, look to Ostuco for practical solutions to their steel tubing problems. Why don't you ask one of our Tubing Engineers to show you how OSTUCO'S PERFORMANCE PLUS service turns drawing-board ideas into top quality parts faster . . . more dependably . . . with greater savings.

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—ITEM 559—

projectiles of various shapes when they enter water. The models range in size from ¼ to 1¼ in. diam and up to 10 in. long. They simulate bombs, airplane-dropped depth charges, torpedoes and rocket-propelled antisubmarine projectiles. Motion and still pictures record the behavior of the projectiles in the water.

Transistorized Computer Takes to the Air

Miniature Calculator Processes Data in Flight

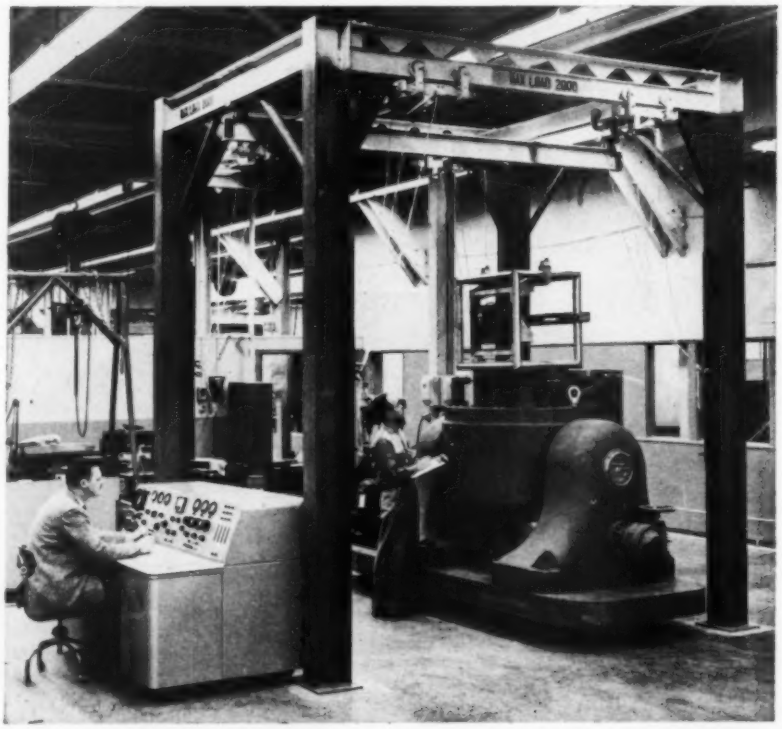
LOS ANGELES—An airborne digital computer using transistors instead of vacuum tubes has been developed by North American Aviation Inc. Successfully flight tested, the machine automatically and continuously processes in-flight data. According to company engineers,

the computer can integrate 93 quantities simultaneously.

Weighing 125 lb, the device occupies 3 cu ft. About 1000 transistors are used. Total power consumption is reported to be about 100 watts.

A vacuum-tube type computer of about one-half the capacity would weigh about four times as much and consume 3000 watts.

Printed circuits account for some of the unit's compactness as well as its ruggedness and light weight. Standardized panels, 51 in all, make up the machine. The panels can be pulled out like file cards for replacement or testing.



An electronic device is shown under test in North American Aviation's powerful electrodynamic vibration exciter. The device is in a simulated airframe mounting. Control console for the "big shaker" system is at the left

Big Shaker Subjects Aircraft Parts to 45g

Nine-Ton Unit Handles Large Components

DOWNEY, CALIF. — An electrodynamic vibration exciter which can subject test equipment items to 45 times the force of gravity is now in use at the North American Aviation Environmental Laboratory. The 9-ton shaker system is used to determine the vibration capacity of components before their incorporation in supersonic aircraft and guided missiles. It will accommodate large items and has a continuous force output of 12,500 lb.

Items are mounted or suspended for testing on a 27-in. diameter magnesium table. This table, together with its associated 272-lb armature coil, is shaken electromagnetically. Four forged-steel legs support the table and ensure straight-line motion with almost no disturbing resonances.

The complete shaker system, developed by MB Mfg. Co. Inc., consists of a vibrating exciter, an integrated power supply unit, and a control console. Operating frequency of the vibration exciter ranges from 2 to 2000 cycles per second. Automatic direct servo controls for maintaining a desired displacement level or force level are included, and automatic changeover from constant displacement to constant acceleration at any level or desired frequency can be made.

Immersion Gives Coat of Anti-Rust Plastic

CLEVELAND, O.—A new process for providing corrosion-resistant coatings of polyethylenes, polyfluorocarbons, nylon and other plastics on metallic and dissimilar plastic molded objects was announced recently by the American Agile Corp. The new process is known as fluidized coating and is said to be particularly useful for small size parts or irregular shapes.

Dr. J. A. Neumann, Agile president and director of research, said

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Critical customers from coast-to-coast depend upon us for top quality. Year after year, whether their needs are numbered in hundreds or thousands, they get a degree of UNIFORM accuracy *unapproached by any other Small Gear manufacturer in the world!* That assures smooth, dependable performance and low assembly costs. Rejects disappear or reach an all-time low. ★ Chances are you, too, can improve quality, speed production, and cut costs with the much better Small Gearing we make. Capable G. S. engineers will gladly help you develop the ONE best and most economical design for your specific needs. Send drawings and specifications or a complete description. Suggestions, ideas, and cost estimates don't obligate you. Write or wire today.

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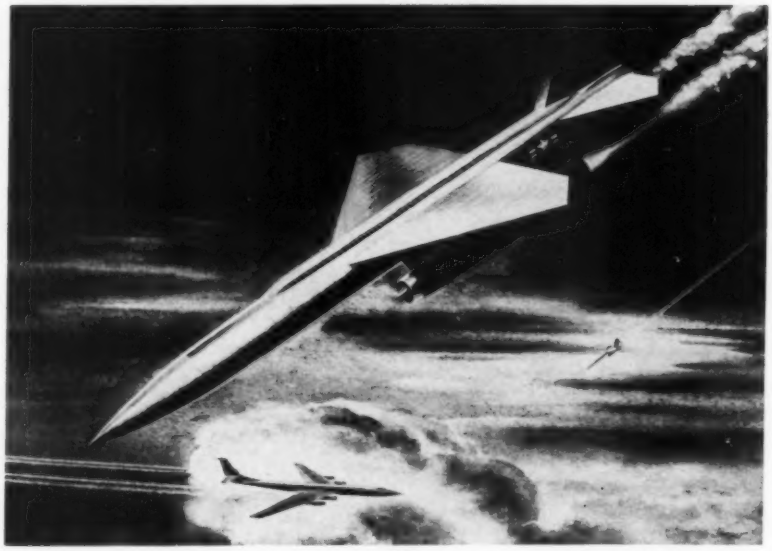
40 Years of Specializing in Small Gearing!

—ITEM 560—
For More Information Circle Item Number on Yellow Card—page 19

that the fluidized coating process will enable industry to apply on-the-spot corrosion protection when and where it is needed, at low cost, and in half the time required for spraying.

The process involves the use of a Powder Fluidizer, a compact unit consisting of a specially designed gas distribution system which maintains the plastic powder in a turbulent, dense fluid state. The process provides a uniform coating up to 3/16-in. thick. The target to be coated is first preheated to a certain temperature, then immersed in the fluidized coating powder for 10 to 15 seconds. It is then returned to the oven where the coating is allowed to cure.

For the present, the process is available only on a laboratory scale for coating such items as stirrers, valves, containers, racks and handling tools. As larger coating units are built, however, applications to industry in general will be possible.



"BOMARC" PILOTLESS INTERCEPTOR, currently under development at Boeing Airplane Co., will look something like this when completed. To build this missile, Boeing is drawing on experience from an earlier program in which it developed similar craft, 16 ft long, that travelled 1500 mph. No doubt "Bomarc" will make a big noise eventually, but for the present military security requires hush on details

TOUGH NEW TUG is the Pennsylvania Railroad's all-welded "Buffalo" recently placed in service in New York harbor. Design feature of the craft is its hull made of 1⅛-in. vertical steel plates heavily reinforced. The hull takes impact of tug and lighters without the use of fenders. Length of the "Buffalo" is 105 ft; beam 26 ft. Its 12-cylinder G-M diesel-electric plant delivers 1000 shaft hp. In a proposed large family of working-girls, the next sister to the "Buffalo" is the "Cleveland"

Plastics Make Lighter Machine Tool Housings

New Housings Feature Low Cost, Easy Handling

NEW YORK — Housings for machine tools made of reinforced plastic have been developed by Gisholt Machine Co. A compound of polyester resin combined with glass fiber makes up the reinforced plastic structure.

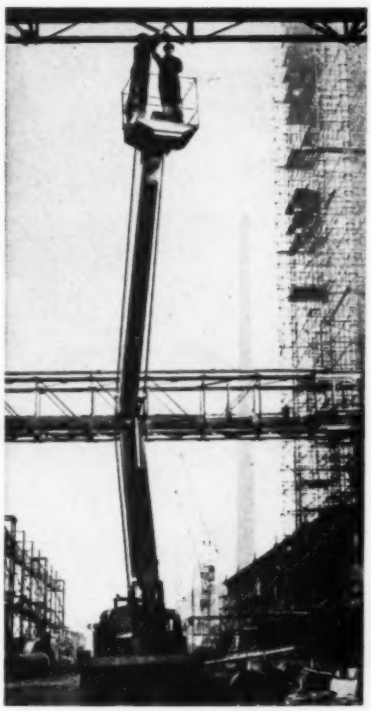
According to Bakelite Co., suppliers of the polyester resins, savings in production costs amount to about 30 per cent of the cost of a metal housing for a vertical automatic lathe. Other advantages include ease of handling and lower repair and maintenance costs. Strength or utility is not sacrificed, according to reports.

In fabricating the housings, glass fiber sheets are laid over a production mold and polyester resins brushed on. The parts come from the mold with a finished surface that requires no machining, sanding, chipping or grinding.

Because of their light weight, typical panels may be lifted off the

machine by hand rather than with a chain hoist. A typical plastic housing for an automatic vertical turret lathe weighs about 37 lb compared to about 300 lb for a cast iron cover.

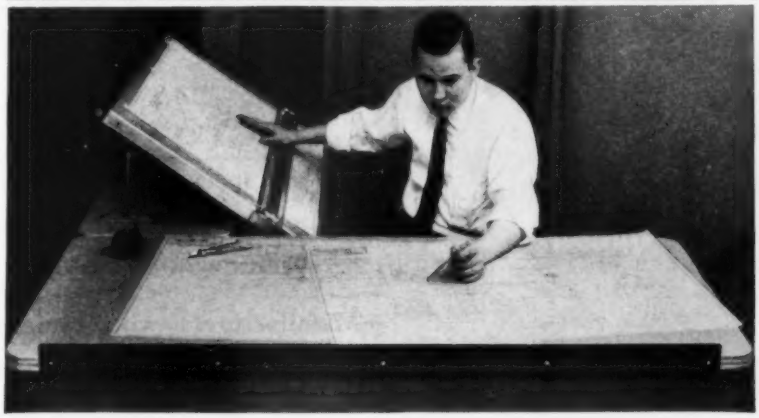
Housings made of the reinforced plastic have been found to resist abrasion from flying metal chips or shavings. Grease, oil, moisture and many other solvents employed in the machine tool industry do not affect the plastic housings.



LONG JOINTED ARM lifts construction workmen on a platform to a height of 40 ft. Hydraulic operation is provided by a pump driven by a small motor. All movements of the platform are controlled from that point, by pedals for raising and lowering and by a knee-operated rotation control. Built by Simon Hydraulic Machinery, England, the lift replaces scaffolding or block-and-pulley rigs used on building construction jobs

Materials used in nuclear energy development will be the subject of proposed standards investigations by the American Society for Test-

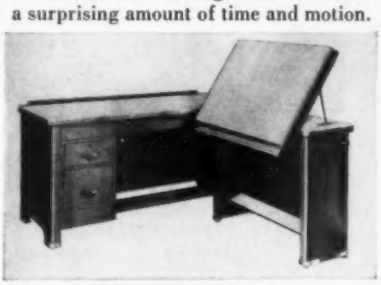
(*Continued on Page 22*)



New "L" angle drafting table saves motion

A new drafting table may change the working habits of many draftsmen within the next 12 months. After years of experimentation, the new table has gone into production at the Hamilton Manufacturing Company and will be distributed by Post.

Designed as an "L", the steel table has a complete reference area at a right angle to the drawing board (see photo). Unlike many table arrangements in which the draftsman must turn around completely, or leave his board altogether, the new table consolidates the entire working area—the reference desk is never more than a slight turn from the board. This arrangement conserves a surprising amount of time and motion.



Reference desk is 28" x 60" and contains 3 drawers. The board itself is 26" x 40".

Like Hamilton's *Auto-Shift* table, the new "L" table adjusts easily and quickly. A hand trip permits slope adjustments to any angle from vertical to horizontal. Another release frees the board for height adjustment through a range of 8". These convenient adjustments are easy to operate and step up efficiency. Many executives have reported substantial production increases using this type of adjustment ■

Another motion-saver: "Boardmaster" drafting machine

While very helpful on the board, many drafting machines have characteristics which almost nullify their value—blind spots, awkwardly placed controls, slippage in control settings, etc.

The Universal "Boardmaster" drafting machine solves many of these problems. Its overarm construction allows complete visibility of the protractor at all times. The controls are all *centrally located*—conveniently placed for manipulation by two fingers.

The indexing control has a push-button action that provides automatic indexing every 15°. The vernier clamp has an ingenious double wing lever for locking intermediate angle settings.

Aside from operating ease, the "Boardmaster" meets the highest standards for accuracy. We believe it to be the finest drafting machine available.

Further information on these items is available from the Reader Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

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We are specialists in the custom-building of the types of gears shown here. We make them in quantity to your specifications.

Manufacturers who want that kind of wide specialization—and who are looking for a company that can serve as a "gear department" are indeed invited to write or phone. The answer will be prompt.

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SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

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for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 136

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 144

MACHINE DESIGN
APR. 5, 1956

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403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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Compare These HOLO-KROME Features!

COMPLETELY FORGED SOCKET HEAD . . . no drilling or broaching—metal fibers stay intact for stronger hex sockets.

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

SHARP HEX CORNERS . . . carefully formed socket corners resist internal reaming.

UNTAPERED WALLS . . . for better key fit, longer key life, even tighter wrenching.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE—the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE a H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

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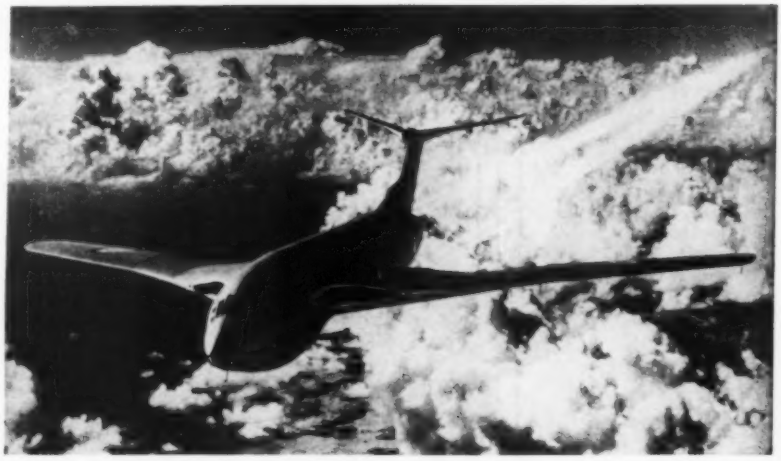
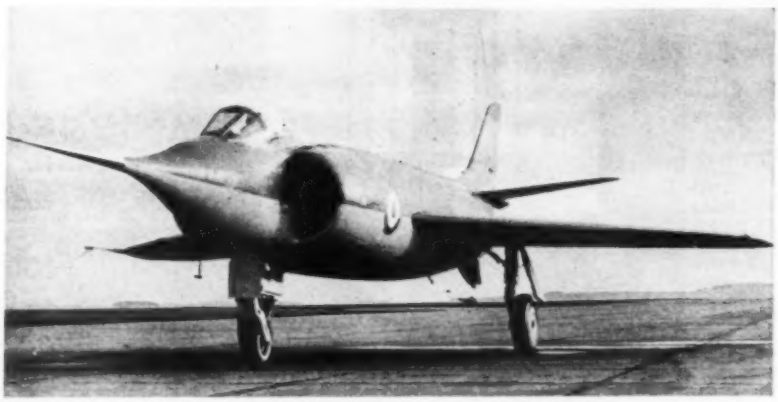
—ITEM 563—

Engineering News Roundup

New British Military Aircraft



EASY LET-DOWN has been demonstrated a distinctive landing characteristic of Britain's new Handley Page Victor bomber. Distinctive, too, is its crescent-shaped wing. The plane is powered by four Armstrong-Siddeley Sapphire jet engines that take in air through scoops in the wing roots. Operational speed is said to be 700 mph up to 60,000 ft altitude



SUPERCIRCULATION SYSTEM in the swept-wing Vickers Supermarine N.113 permits reduction of speed for landing on aircraft carrier decks. Air ducted from the engine compressor flows over the high-lift wing flaps, increasing the lift. Saw-tooth shape of the wings' leading edges and completely movable tail facilitate control at high speeds. Built for the British Royal Navy, the N.113 will be equipped to carry guided missiles as well as guns. It is powered by two Rolls-Royce Avon turbojet engines

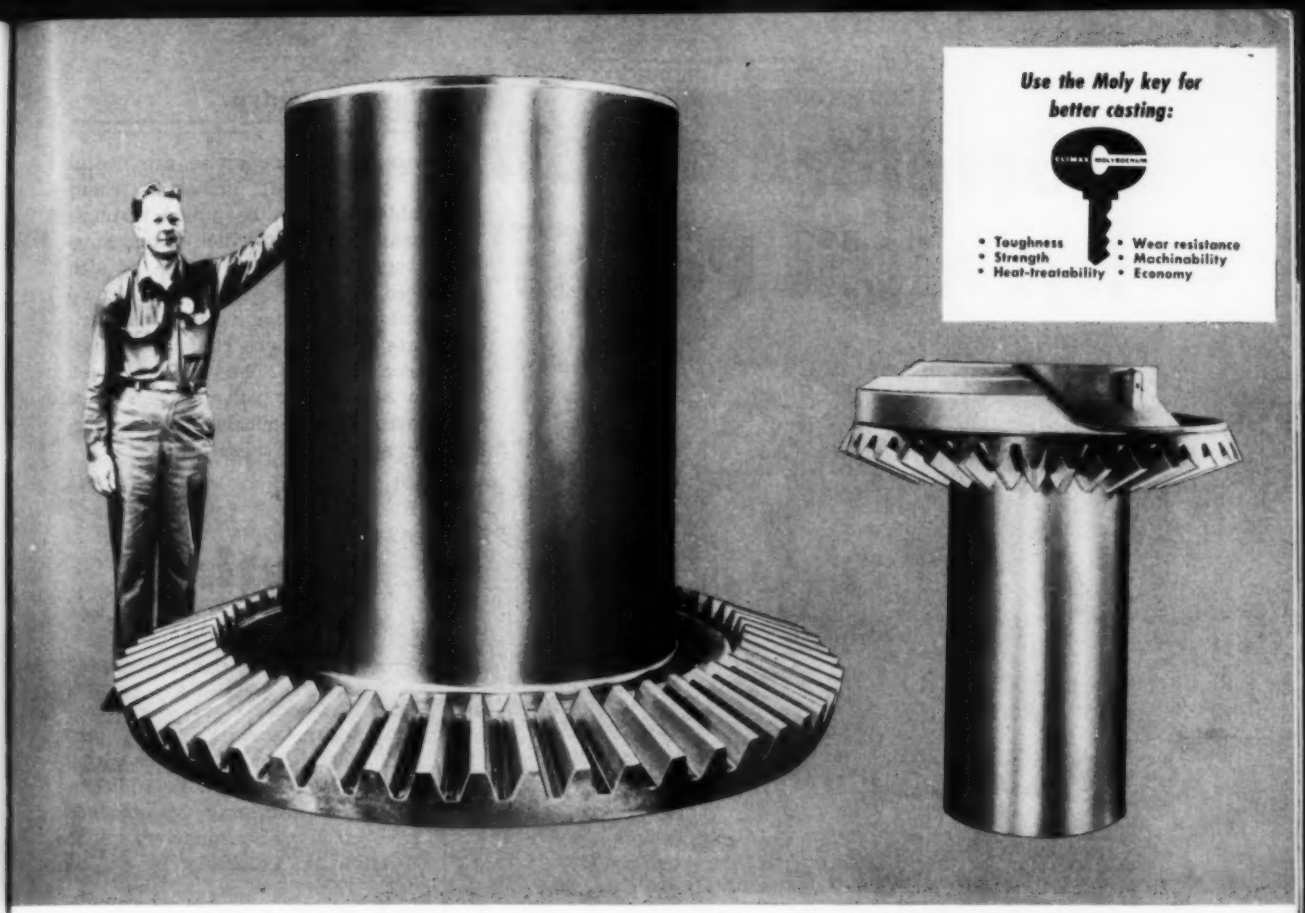
(*Continued from Page* 15)

ing Materials. A special Administrative Committee has been organized to conduct the studies. Scope of the new group is (1) to advise the technical committees of the Society on nuclear problems, and (2) to stimulate the undertaking of research and standardization projects specifically related to nuclear energy, and (3) to review periodically the status of the work.

Fibers in Glass Yarn All Plastic Coated

TOLEDO, O. — New glass yarn, in which all the strands have individual coatings of DuPont Teflon, has been announced by L.O.F Glass Fibers Co. Previously, glass yarn was braided and then coated with the plastic.

Properties of the new yarn are abrasion resistance and slipperi-

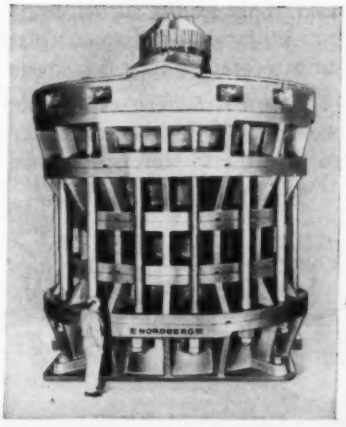


Heavy duty ore crushing machinery is subjected to severe operating conditions. To meet these strenuous requirements the gears shown are made from heat treated low-alloy manganese-*Molybdenum* steel castings. At left: a Symons Gyratory Crusher gear; right: a Symons Cone Crusher gear. Built by Nordberg Mfg. Co.

Cast Manganese Moly Steel contributes strength and toughness to Crushers built by Nordberg

"Where high strength and toughness are prime considerations," says Howard Zoerb, Consulting Engineer of the Nordberg Crusher Division, "molybdenum bearing steels are specified. This is true of the heavy duty parts of Symons® Crushers, built by Nordberg. These steels have contributed to the Nordberg reputation as producers of dependable, heavy duty crushing machinery."

Technical assistance is available to foundries on alloying problems. Please address inquiries on your foundry letterhead to: Climax Molybdenum Company, Department MF11, 500 Fifth Avenue, New York 36, New York.



The Symons Cone Crusher is a product of Nordberg Manufacturing Company.

CLIMAX MOLYBDENUM

ness. Both properties are useful in the aircraft industry, where cables have to be pulled through small openings, which often have rough edges. The yarn is also used in Navy cable, coaxial cable and as a sewing thread to fabricate items where chemical resistance is desired. The yarn is claimed to be inert to solvents and most corrossive chemicals. It has nearly zero water absorption.

Meetings

AND EXPOSITIONS

April 22-26—

American Ceramic Society. Annual Meeting to be held at Hotel Statler, New York, N. Y. Additional information may be obtained from society headquarters, 4055 N. High St., Columbus 14, O.

April 23-May 4—

British Industries Fair to be held at Olympia Hall, London, England. Additional information may be obtained from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y.

April 26-27—

Management Engineering Confererence to be held at Hotel Statler, New York, N. Y. Sponsored by the American Society of Mechanical Engineers and the Society for Advancement of Management. Additional information may be obtained from S.A.M. headquarters, 74 Fifth Ave., New York 11, N. Y.

April 29-May 3—

Electrochemical Society. Spring Meeting to be held at Mark Hopkins Hotel, San Francisco, Calif. Additional information may be obtained from society headquarters, 216 W. 102nd St., New York 25, N. Y.

April 30-May 2—

Association of Iron and Steel Engineers. Spring Meeting to be held at the Lord Baltimore Hotel, Baltimore, Md. Additional information may be obtained from society

headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

April 30-May 2—

Metal Treating Institute. Spring Meeting to be held at the Roosevelt Hotel, New Orleans, La. C. E. Herington, 271 North Ave., New Rochelle, N. Y., is secretary.

May 2-4—

Industrial Fasteners Institute. Annual Meeting to be held at the Homestead, Hot Springs, Va. R. B. Belford, 1517 Terminal Tower, Cleveland 13, O., is secretary.

May 2-4—

Investment Casting Institute. Spring Meeting and Exhibit to be held at the Warwick Hotel, New York, N. Y. Harry P. Dolan, 27 E. Monroe St., Chicago 3, Ill., is executive secretary.

May 3-4—

Society of Naval Architects and Marine Engineers. Annual Spring Meeting to be held at the Sheraton-Mt. Royal Hotel in Montreal, Quebec, Canada. Additional information may be obtained from Harold M. Wich, Chairman, Public Relations Committee, SNA&ME, c/o American Bureau of Shipping, 45 Broad St., New York 4, N. Y.

May 3-9—

American Foundrymen's Society. Biennial Convention and Show to be held at Convention Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, Golf & Wolf Rds., Des Plaines, Ill.

May 4—

Annual Conference for Engineers to be held at the Ohio Union, Columbus, Ohio. Sponsored by the College of Engineering at Ohio State University. Additional information may be obtained from Harold A. Bolz, Associate Dean, College of Engineering, Ohio State University, Columbus 10, O.

May 7-11—

American Welding Society. National Spring Technical Meeting and Welding Show to be held at Hotel Statler and Memorial Audi-

News Roundup

torium, Buffalo, N. Y. Additional information may be obtained from society headquarters, 33 W. 39th St., New York 18, N. Y.

May 8-11—

American Society of Mechanical Engineers. Metals Engineering-AWS Conference to be held at Hotel Statler, Buffalo, N. Y. Additional information may be obtained from society headquarters, 29 W. 39th St., New York, N. Y.

May 9-19—

Mechanical Handling Exhibition and Convention to be held at Earls Court, London, England. Additional information may be obtained from Exhibition Manager, Dorset House, Stamford St., London, S.E. 1, England.

May 14-17—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 16-18—

Anti-Friction Bearing Manufacturers Association. Annual Meeting to be held at Princeton Inn, Princeton, N. J. H. O. Smith, 60 E. 42nd St., New York 17, N. Y. is secretary.

May 16-18—

Society for Experimental Stress Analysis. Spring Meeting to be held at the William Penn Hotel, Pittsburgh, Pa. Dr. W. M. Murray, P. O. Box 168, Cambridge 38, Mass. is secretary-treasurer.

May 23-24—

American Iron & Steel Institute. Annual Meeting to be held at the Waldorf-Astoria, New York, N. Y. George S. Rose, 350 Fifth Ave., New York 1, N. Y. is secretary.

May 23-25—

American Society of Mechanical Engineers — Engineering Institute of Canada. Meeting to be held at the Mount Royal Hotel, Montreal, Quebec, Canada. Additional information may be obtained from A.S.M.E. headquarters, 29 W. 39th St., New York, N. Y.

News Roundup

May 23-26—

National Society of Professional Engineers. Annual Meeting to be held at the Ambassador Hotel, Atlantic City, N. J. Additional information may be obtained from society headquarters, 2029 K St., NW, Washington 6, D. C.

May 24-25—

National Warm Air Heating & Air Conditioning Association. First Technical Conference to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 640 Engineers Bldg., Cleveland 14, O.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13. O.

May 28-30—

National Fluid Power Association. Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Barrett Rogers, 1618 Orrington Ave., Evanston, Ill., is executive secretary.

June 3-6—

American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. John C. Sears, One Thomas Circle, Washington, D. C., is executive secretary.

June 3-8—

Society of Automotive Engineers Inc. Summer Meeting to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

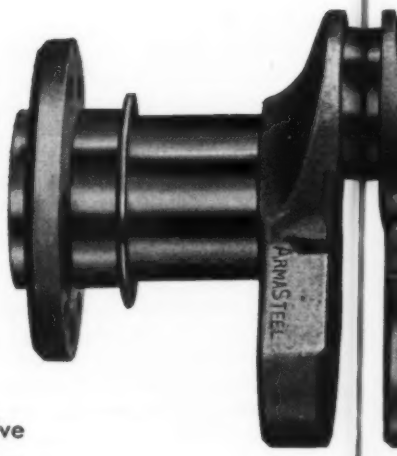
June 5-8—

Material Handling Institute Inc. Material Handling Exposition to be held at the Public Auditorium, Cleveland, O. Additional information may be obtained from society headquarters, One Gateway Center, Pittsburgh 22, Pa.

—ITEM 569—

Next Page—ITEM 570→

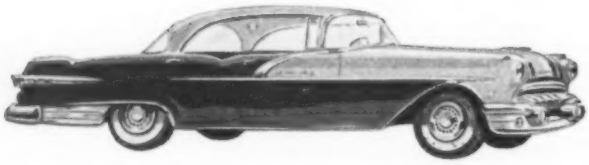
WHY PONTIAC SWITCHED SHELL-CAST CRANKSHAFTS



For many years automotive engineers have sought to produce a successful *cast crankshaft*. But either the material or the method of casting did not give the desired results. Now, however, Central Foundry Division has solved both problems by means of their tough pearlitic malleable iron, ARMASTEEL, and their perfected shell molding process. Pontiac Motor Division is the first of the great automobile manufacturers to capitalize on the advantages of the new ARMASTEEL crankshafts. After conducting a long and exhaustive series of tests in the laboratory and on the road, Pontiac is now installing shell-cast ArmaSteel crankshafts in all 1956 models.

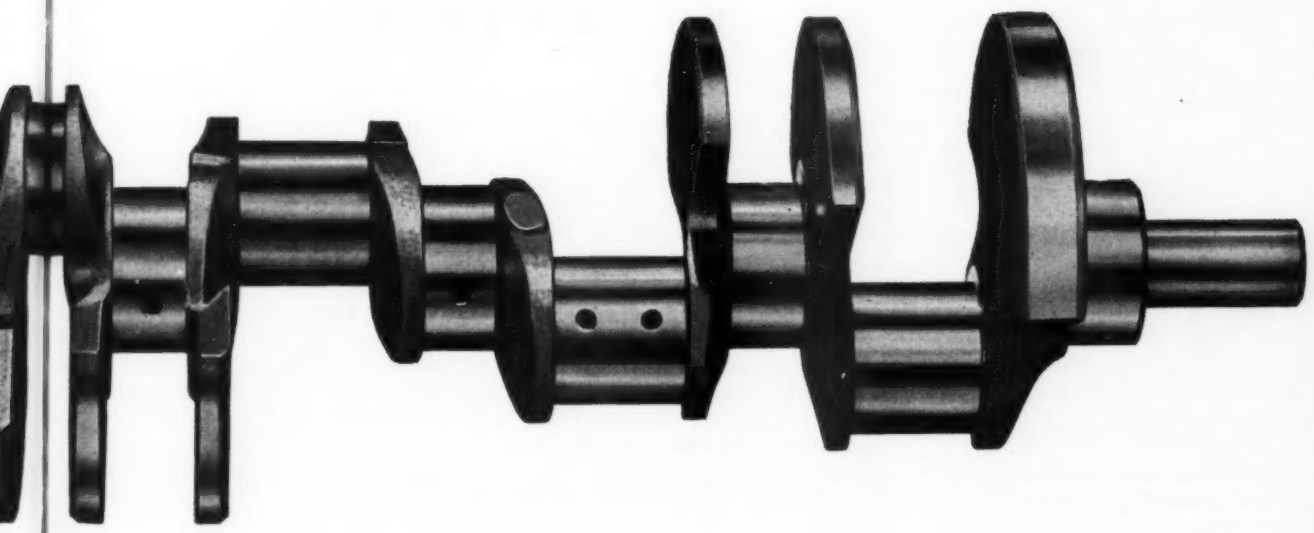
ARMASTEEL, the metal, is a triumph of modern metallurgy that combines the advantages of both castings and forgings. Its resistance to fatigue and wear assures long life. Its rigidity results in minimum deflection and accurate alignment. Its high damping capacity allows it to absorb vibrant energy and thus contribute to noiseless operation.

The crankshaft, made by the shell-mold process at Central Foundry, results in substantial manufacturing savings. Because the castings are so close to the final finished dimensions, shell-cast ArmaSteel crankshafts are lighter and require considerably less machining and finishing.



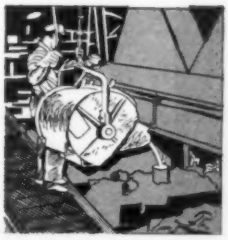
Many manufactured products can be improved and the costs lowered with shell-cast ARMASTEEL. If you are a manufacturer, engineer, production man or purchasing director, it will pay you to write us today for your copy of the book "ARMASTEEL" and the pamphlet "Shell Molding at Central Foundry".

TO ARMASTEEL

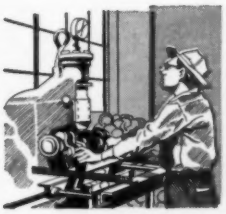


BETTER MATERIALS, BETTER METHODS, LESS MACHINING AND THOROUGH TESTING MEANS BETTER CRANKSHAFTS FOR PONTIAC

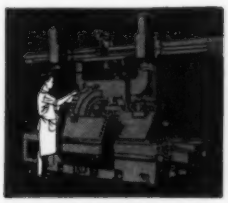
SHELL MOLDING allows metal to be poured exactly where it is needed. Tolerances can be so close that finishing can be reduced and, in some areas, eliminated. The shell mold gives the engineer considerably greater latitude in design.



ARMASTEEL is a pearlitic malleable iron with characteristics of low carbon steels produced only at Central Foundry Division of General Motors Corporation. Its machinability is rated 33⅓% better than SAE 1045 steel. It is uniform in structure, possesses excellent bearing qualities, responds readily to localized hardening, and is a material of exceptional rigidity.



MODERN TESTING techniques in the new shell-cast ARMASTEEL crankshafts include gamma-ray radiography, 100% magnetic particle inspection and sonic testing (a Central Foundry development) on each individual crankshaft.



LESS MACHINING and finishing is required with shell-cast ARMASTEEL crankshafts. Rack-to-rack lathe cycle time on in-line diameters, for example, was cut in half! Cutter and grinding wheel life is increased in all machining operations.

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION

SAGINAW, MICHIGAN · DEPT. 14

84

MEN OF MACHINES

Formerly chief engineer for conveyor equipment, **B. G. Schneider** has been named chief engineer of the Conveyor and Process Equipment Div. of Chain Belt Co., Milwaukee.

B. W. Bogan has been named to the newly created position of executive engineer of the Dodge Div. of Chrysler Corp., Detroit. He is responsible for all car and truck engineering activities of the division. Mr. Bogan joined the Chrysler Corp. as a student engineer in 1933. Assigned to the company's central engineering group, he served in various laboratory, production and research supervisory positions. He has been chief engineer of the Dodge Div. for six years.

B. W. Bogan

Actuation Research Corp., Glendale, Calif., has announced the election of **Richard D. Maystead** as president. Mr. Maystead was vice president and chief engineer of Talley Machine & Mfg. Co.

Raymond A. Rugge has been elected vice president in charge of the Research and Development Div. of W. L. Maxson Corp., New York. Mr. Rugge was associated with the Minneapolis-Honeywell Regulator Co., first as chief engineer of the Aeronautical Div. and, more recently, as assistant director of aeronautical engineering. Previously, he was affiliated with Lear Inc. and Curtiss-Wright Corp.

Promotion of **John P. Moffat Jr.** to assistant director of quality control has been announced by Consolidated Electrodynamics Corp., Pasadena, Calif. Mr. Moffat joined the company in 1952 as a test engineer and was promoted to group supervisor of quality control in 1954.

William P. Downey has been promoted to supervising engineer of the Straddle Truck Div. of the Hyster Co., Portland, Ore. Mr. Downey has been associated with Hyster for over 14 years. Previously he was an engineer for

William P. Downey

XUM

Men of Machines

Moore Dry Kiln Co., manufacturer of lumber drying and handling equipment.

United States Testing Co. has appointed **Paul E. Fleming** senior administrative engineer in the mechanical engineering department of its Hoboken, N. J. laboratories.

To direct design engineering of the company's line of axle assemblies, **E. Walter Hammer Jr.** has been named chief engineer by United Mfg. Co., Cleveland. Mr. Hammer had been associated with the Franklin Institute Laboratories for ten years, the last year as chief of the Machine Design and Development Section for research and development.

Paul H. Crago recently joined C. P. Clare & Co., Chicago, as an electrical engineer. He was formerly co-ordinator of engineering for Askania Regulator Co.

York-Gillespie Mfg. Co., Pittsburgh, has named **R. G. Dragar** chief engineer. He will be in charge of designing all new machinery developed by the company. Mr. Dragar was chief draftsman for Mackintosh-Hemphill Co. and Atlas Steels Ltd. of Canada. He has also served in the engineering departments of Mesta Machine Co., United Engineering & Foundry

R. G. Dragar

Co. and Birdsboro Steel Foundry & Machine Co.

John W. James was elected president of the American Society of Heating and Air-Conditioning Engineers at the society's recent annual meeting. Mr. James is vice president of research for McDonnell & Miller Inc., Chicago.

Rudd-Melikian Inc., Hatboro, Pa., has appointed former chief engineer **George R. Scollhamer** to director of manufacturing. **Leonard I. Kownurko** has been named chief engineer of all departments.

Arthur H. Mankin has been named head of the newly established dynamotor department of Induction Motors Corp., Westbury, L. I., N. Y. Mr. Mankin was chief development engineer at Electro Engineering Products Co. Inc.

Servomechanisms Inc., Westbury, L. I., N. Y., has announced the appointment of **Ira L. Kasindorf** to the position of chief development engineer of its Eastern Components Div.

Taylor Devices Inc., a manufacturing concern, and Tayco Developments Inc., a research company, have been formed in North Tonawanda, N. Y., for the manufacture and development of compressible material devices. **Paul H. Taylor,** president, was associated with Curtiss-Wright Corp. for seven years in patent and development engineering, and for the last nine years was a vice president and director of patents and research of the Hydra Spring Div. of Wales-Strippit Corp.

Worthington Corp., Harrison, N. J., has promoted **I. J. Karassik** to assistant to the vice president and consulting engineer at the Harrison Div.

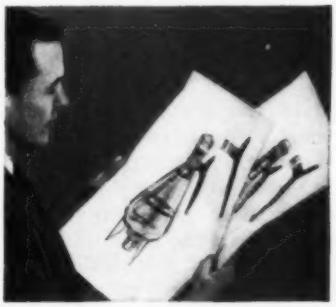
William W. Dickhart III recently was named chief of the Machine Design and Development Section of the Franklin Institute Laboratories, Philadelphia. He has been a member of the Laboratories' Engineering Mechanics Section.

—ITEM 574— Next Page—ITEM 575→

MONSANTO

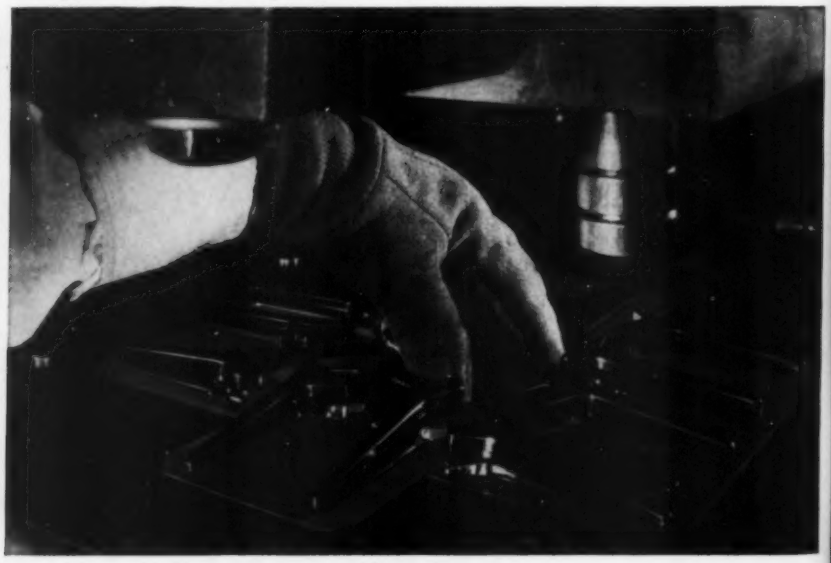
Feverish competition in today's giftware market gives industrial designers many a sleepless night. Forever foremost is the challenge to be first with something new, something better. Read how, by working closely with plastics engineers in the custom molding industry, one of America's leading manufacturers pioneered a winner which utilizes the unique properties offered by plastic materials.

How handles of Resinox phenolic plastic are high-styling Inland Carafes



DESIGN OBJECTIVES. To restyle the conventional coffee carafe with a handle that would both enhance the beauty of the unit and facilitate its pouring. When the Inland Glass Works Division of the Club Aluminum Products Company gave the project to its designers, they were instructed to keep appearance and functionalism uppermost in their plans. Moderate cost was a secondary, but important, consideration.

MATERIAL SPECIFICATION. Designs dictated that the handle be riveted to a 1-inch metal band at the neck of a cone-shaped bottle. Because the center of gravity was extremely low (far below the fulcrum of the handle), a material of outstanding strength was required. Steel was rejected—its high heat absorption made the handle uncomfortable to hold. Wood was rejected—it has a tendency to split with the grain and demanded an additional, expensive finishing step. Selection was narrowed down to a phenolic plastic. This material is both flame- and heat-resistant, has the moldability, inherent color and surface smoothness to permit optimum flexibility in design. (Inland Glass had long been using phenolic plastics with great success on other giftware items.)



PRODUCTION ENGINEERING. The custom molding job was awarded to Ackerman Plastic Molding Company, Div. Consolidated Iron-Steel Manufacturing Company of Cleveland, Ohio, whose engineers specified Monsanto's Resinox 1004—a phenol-formaldehyde high-luster plastic with a superior impact strength of .34 foot pounds per inch. The fast flow and curing properties of Resinox 1004 permit non-critical transfer molding at 325° F. Molding powder is preformed into "pills," heated in an electronic oven and placed in the plunger mold. After a 70-second cycle, the "shot" containing 12 molded handles is removed and separated from the runners. The surface of the molded handles has been consistently mirror-smooth. Another vital property of Resinox 1004 compound is strength to resist cracking when metal rivets are inserted into molded-in handle holes and expanded to grip the plastic handle to the metal neck sleeve.

THE FINISHED PRODUCT. Elite Carafes are now smartly serving coffee in more than 800,000 homes. The jet black handles which gracefully parallel the contours of the flask need no finish. Their ebon beauty will never peel or chip—and accentuates the decorative stripings in copper and platinum. Styling like this has made Inland-Glass one of the leaders in its field.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Applications Dept., Springfield 2, Mass.

Investigate Monsanto's completely balanced line of phenolic plastic compounds developed for particular applications and sold under the trade name . . .

RESINOX®

MONSANTO

YOUR "SPECIAL" TIMER
may be one of our
721 STANDARD UNITS!

We have 20 years of experience in developing new timers to meet our customers' widely varying requirements. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why most requests for special timers can be filled without delay—by one of the 721 combinations we've developed so far from our 17 basic types of timers. But if we don't have what you want on hand, we'll welcome the chance to design and make it for you! And quickly too!

We manufacture a complete line of timers in these 4 broad classifications:

INTERVAL TIMERS • TIME DELAY TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

Our large stock assures you of rapid deliveries—even when we have to create a brand new timer for your special needs. Ask us first—you may save yourself much lost motion . . . and your inquiry will receive prompt attention.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

—ITEM 576—
For More Information Circle Item Number on Yellow Card—page 19

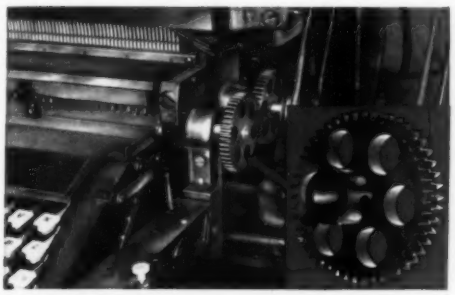
Facing Page—ITEM 577→

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living ... through Chemistry

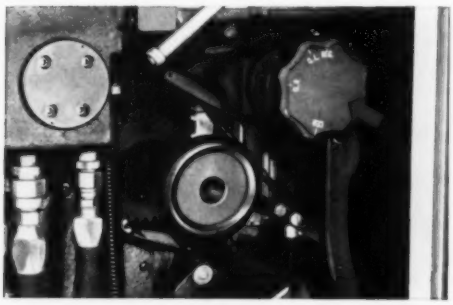
PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

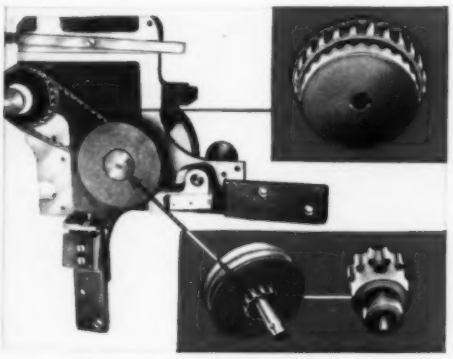
Parts of ZYTEL® nylon resin outperform conventional materials in six linotype machine applications



Gears for rubber keyboard rolls
Gears of "Zytel" are noiseless, require no lubrication and show no wear, even after years of service. These parts were formerly made of cast iron.

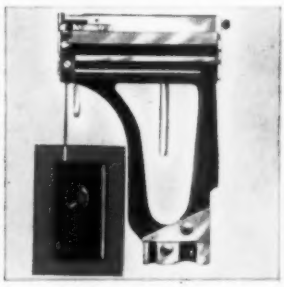


Selector handle control knob
"Zytel" reduces weight and inertia—gives better appearance and "feel" than the conventional material it replaced.

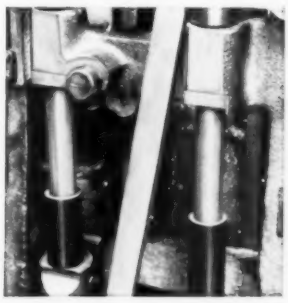


Assembler pulley and star sprocket
Molded "Zytel" cuts the expense of specially shaped teeth on parts formerly made of steel, gives top wear resistance.

Assembler star
Replacement was more frequent when this part was made of a fiber material. "Zytel" withstands the constant friction and impact; costs less to manufacture.



Matrix buffer
"Zytel" replaces fiber material in this part, offering three times the working life and reducing the cost substantially.



Stop sleeves
Subjected to heavy impact, these sleeves are now made of "Zytel". They offer the advantages of closer dimensional control in manufacture and reduction of noise in operation.

Du Pont "Zytel" offers superior strength, abrasion resistance and resiliency

ON THE highly-complicated, fast-running linotype machine, Du Pont "Zytel" has proved extremely valuable as an engineering material. Molded parts of "Zytel" have helped the manufacturer of the machine, Mergenthaler Linotype Company, to achieve better performance at lower cost.

On this type of machine, many parts are constantly in motion and subject to wear. Molded parts of "Zytel" have shown their ability to stand up under the most rugged service. They have exhibited unusual wear resistance and impact strength, helped to reduce noise, eliminate the need for lubrication wherever they are used.

Molded parts of "Zytel" have proved less expensive to manufacture than parts made of other materials. Also, parts of "Zytel" can be colored for easy identification by maintenance men.

To date, six kinds of parts molded of "Zytel" have been installed on the linotype machine. All of these are shown at the left. Much wider use of this engineering material is currently being planned by the machine manufacturer.

"Zytel" is distinguished by its toughness, form stability at high temperatures, and chemical resistance. It has high hardness value, together with a low coefficient of friction, which contribute to its excellent abrasion resistance.

Can "Zytel" help solve a design problem for you? Clip and mail the coupon for more information.

OVER

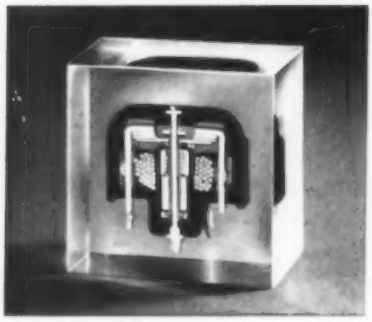
DU PONT

Better Things for Better Living ... through Chemistry

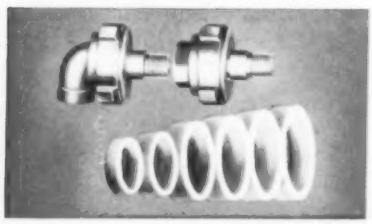
PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

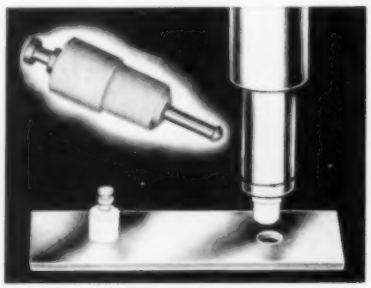
5 examples of how Du Pont engineering materials help solve design problems



LUCITE® acrylic resin adds beauty and durability to embedments, which have a variety of uses. Small items such as electrical components or intricate mechanisms, as well as miniatures of larger products, can be embedded in the "Lucite" either singly or in patterns giving exploded-view effects. These miniature sales showcases can be handled indefinitely without growing grimy and losing their functional and promotional value. (Embedments shown made by Plastic Developments, Inc., Attleboro, Mass.)



TEFLON® tetrafluoroethylene resin in gaskets for swivel joints is without equal for long wear and trouble-free service. Joints maintain their seal under the most adverse conditions. They excel in steam service, perform uniformly within the temperature range of −50°F. to 450°F., are smoother, tougher, and longer wearing—no lubrication ever needed. (Swivel joints by Barco Manufacturing Co., Barrington, Illinois)



TEFLON® tetrafluoroethylene resin is utilized in miniature and subminiature stand-off and feed-through terminals. They cost less than conventional glass or ceramic terminals, and they offer further economy in reduced labor and assembly time.

These terminals of "Teflon" are of a molded, one-piece construction, and can be simply and permanently mounted into chassis holes by press-fitting, using an inexpensive insertion tool. The resiliency of "Teflon" enables these terminals to be pressed in place for rigid and permanent installation without requiring any soldering operations or any other hardware.

The superior electrical, mechanical and chemical properties of "Teflon" further increase the range of application for these miniature terminals. They are tough and remain resilient over a temperature range of −100°C. to 250°C. Dielectric strength of "Teflon" is high over a considerable temperature range. "Teflon" is chemically inert to any known solvents, acids or bases. Terminals can be used in military equipment for tropical use, without additional fungicidal treatment. Terminals will not melt, burn or char. ("Press-Fit" terminals manufactured by the Sealectro Corp., New Rochelle, N.Y.)

These applications are typical of the product improvements made possible when design and service requirements are evaluated in terms of the properties of these unique engineering materials. For further information, mail the coupon below.

ZYTEL® nylon resin is the only material used in the Nylon-Maid shower heads. The inherent chemical resistance of "Zytel" enables these shower heads to function without danger of corrosion. They are easily installed and adjusted. Shower heads of "Zytel" are tough, resilient, and heat-resistant. They offer years of trouble-free service. (Shower heads by Nylon-Maid, Inc., Glendora, California. Parts of "Zytel" by Rainbow Plastics, El Monte, California.)

ALATHON® polyethylene resin has replaced wood in the sticks which act as a knife stop for this paper cutter. The life of "Alathon" is six times greater than that of wood, and tests have shown that the cutting knife will last twice as long when "Alathon" is used. It provides savings in costs and down time. (Cutting stick by Cefaly Experimental Co., Inc., Brentwood, Maryland.)

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 124, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ *"Zytel";* ☐ *"Alathon";* ☐ *"Teflon";* ☐ *"Lucite". I am interested in evaluating these materials for:*

NAME _____ POSITION _____

COMPANY _____

STREET _____

CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon", "Lucite", "Teflon" and "Zytel" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)

Investigate Du Pont engineering materials in your product development programs

One of the family of these versatile engineering materials is often a key factor in product improvement or new product design. The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"* nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION? Clip the coupon for additional data on the properties and application of these Du Pont engineering materials.

He's shooting for perfection

This earnest young man is intent on turning out a perfect sheave. From the looks of the job, we'd say his chances are fine. Best-looking sheave wheel we've seen in quite a while.

He has done his machining with great care, and with complete confidence. That confidence is warranted, for the wheel was first a Bethlehem steel blank, made by Bethlehem's forging-and-rolling process.

If you've never seen this method of manufacture, let us explain it briefly. It employs a mill that is the only one of its kind in the entire country. Blanks are not just forged, not just rolled, but *both*—in a single operation that produces high strength and very desirable grain flow.

That high strength is important. Equally important is the way the blanks machine. In the customer's shop, machinists can do their job with assurance, knowing that the metal underneath is as firm and "sweet" as that on top.

Bethlehem forged-and-rolled blanks are available for a long list of applications, including spur, bevel, miter, and other types of gears; crane and sheave wheels; turbine rotors, clutch drums, brake drums, flywheels, pipe flanges, and numerous others. You can obtain the blanks in sizes from 10 to 42 in. OD, untreated or heat-treated. For full details, ask for Booklet 216; it will be sent to you promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

—ITEM 578—

New trends and developments in designing electrical products . . .

How General Electric Permanent Magnets help designers miniaturize products by supplying constant magnetic field energy in a fraction of the space required by electromagnets

WHERE constant magnetic field energy is necessary, powerful G-E Alnico permanent magnets offer the designer many advantages no electromagnet can match.

The most important of these advantages – from the designer's viewpoint – is the permanent magnet's superior volumetric efficiency. An Alnico permanent magnet can supply a given magnetic field in a fraction of the space required by even the best designed electromagnet.

Since miniaturization has become so vital in the electrical and electronics industries, it is important to see just why and how a permanent magnet utilizes space so much more effectively.

Figure 1 shows a typical magnetization curve of an electromagnet with a flux density of 20,000 gausses, when the polarizing force is 200 oersteds. (The curve has been displaced into the magnetizing quadrant for comparison purposes.)

In a well-designed electromagnet, approximately half the total area is occupied by conductors, and half is flux-conducting core material.

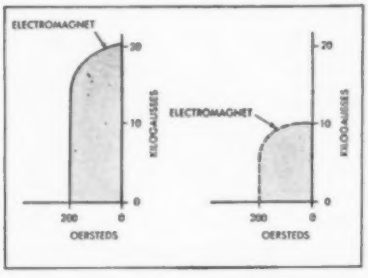


FIGURE 1 FIGURE 2

Therefore, to make the comparison valid, the residual induction of the electromagnet must be reduced to 10,000 gausses (Figure 2).

The area under the curve now represents the approximate external field energy available on a volume basis. When the equivalent demagnetization curve of Alnico 5 is plotted against the corrected electromagnet curve (Figure 3), the true capabilities of each type of magnet become immediately apparent.

The area under the Alnico 5 curve is about three times the area under the electromagnet curve. Thus, to produce a given field requirement, the permanent magnet will occupy a volume one-third that of an equivalent electromagnet.

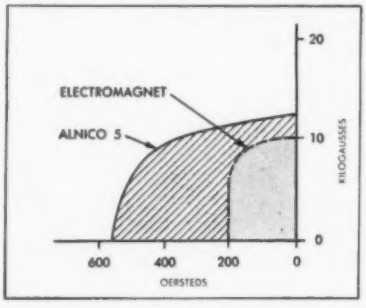


FIGURE 3

The above comparison is somewhat theoretical; under many circumstances, permanent magnets will show to even greater advantage. For example, consider the two TV-tube focusing magnets in Figure 4, at the top of the next column.

At the left, is the electromagnet previously used. It weighed 2 lbs. 13 ounces, and took up 16.35 cubic inches. At right, is the G-E Alnico 5 permanent magnet which replaced it. The new magnet weighs just 15 ounces, and occupies only 1.30 cubic inches – a space saving of 87%!

These savings in size and weight result from permanent magnets' inherent volumetric superiority. In addition, permanent magnets provide equally impressive savings in both initial and service costs because of four other inherent advantages.

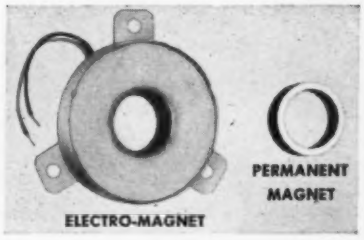


FIGURE 4

First, no power source is required with permanent magnets, because no energy is consumed. Once magnetized, the field is permanently retained.

Second, permanent magnets operate continuously. There can be no interruptions of the field due to power failure.

Third, permanent magnets are extremely stable under changing temperature conditions. They are unaffected by conditions ruinous to electromagnet installations.

Fourth, permanent magnet assemblies are easier to install, and cost nothing to maintain. There are no moving parts to break down, no wiring to burn out, no costly, time-consuming repairs to make.

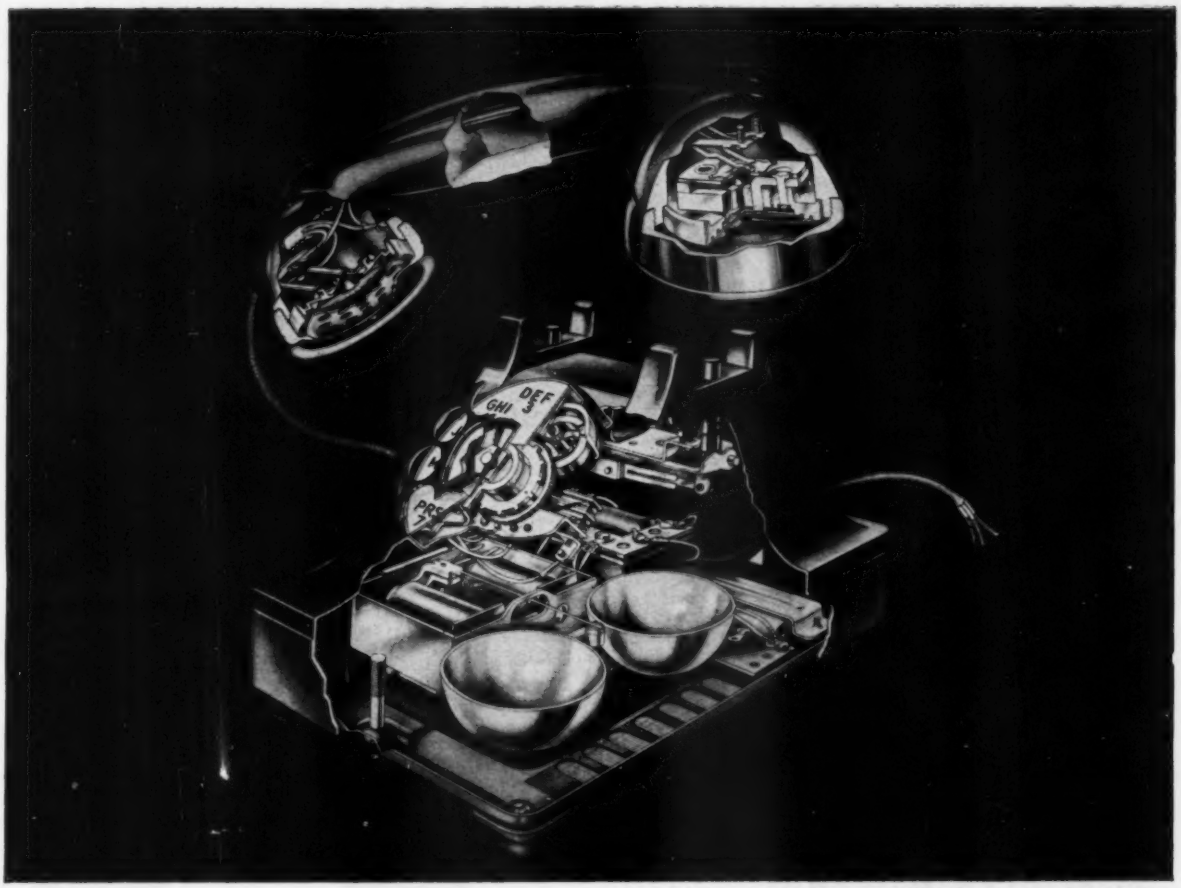
These are but a few of the many reasons why designers are turning to G-E Alnico magnets for products for which only electromagnets had been previously considered.

If you have a problem where constant magnetic field energy is required, one of the G-E Alnico compositions may well be your solution. For more design data or technical assistance from our magnet engineers, write: *Carboloy Department of General Electric Company, 11126 E. 8 Mile Street, Detroit 32, Michigan.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

—ITEM 579—



In critical places your telephone uses COPPER . . . for space-saving, for high electrical conductivity and ease of joining, for dependable performance.

COPPER
speaks for itself!

Everyone who uses copper learns something from it . . . something no substitute can teach.

To the man who machines or stamps or draws metals, copper and its alloys speak of easy workability.

To the firm that uses copper parts instead of substitutes, copper tells the story of satisfaction . . . of standing up in service.

To the designer of complicated equipment, copper offers savings in valuable space . . . permits "miniaturization".

And to the home-owner wise enough to install copper throughout his "castle", time itself tells an unending tale of trouble-free enjoyment.

Copper will speak for your product, too. It will signify *quality!*

It costs you less to make your product well, before it is sold . . . than to make it good, afterwards.

COPPER & BRASS
RESEARCH ASSOCIATION
420 Lexington Avenue, New York 17, N. Y.

. . . AN INDUSTRY SOURCE OF TECHNOLOGICAL AID, INCLUDING A LIBRARY OF TECHNICAL LITERATURE AND A COUNCIL OF SPECIALISTS

COPPER OR ITS ALLOYS PROVIDE THESE ADVANTAGES:

Best conductor of electricity commercially available

Does not rust . . . high corrosion resistance

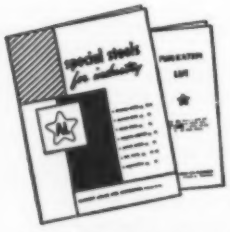
Best heat transfer agent of all commercial metals

Easy to machine, form, draw, stamp, polish, plate, etc.

Welds readily . . . excellent for soldering and brazing

—ITEM 580—

NOTHING PROTECTS LIKE STAINLESS STEEL



WRITE TODAY
For These Publications

1. SPECIAL STEELS FOR INDUSTRY . . . 16 pages of essential data on the proper selection and application of principal AL special alloy products: stainless, tool and electrical steels and sintered carbides.

2. PUBLICATION LIST . . . a complete listing of all AL publications, both technical and nontechnical (over 100 in all), with a handy order form for your convenience.

ADDRESS DEPT. MD-76

In the world of products and equipment, just as in Nature, *protection* is the difference between a long life and a too-early end.

Many materials are good-looking. Some are strong. Some resist corrosion. But not one other commercially-available material offers the same combination of beauty, high strength, high hardness and resistance to corrosion, heat and wear that stainless steel can give you. Not one has the ability to protect as completely, last as long and cost you as little in the long run.

These qualities in AL Stainless Steel can boost the salespower of a product, or cut the operating costs of equipment—often with little or no increase in first cost. Very likely *you* have problems where these advantages can bring you benefits. Let us work with you. ***Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pennsylvania.***

WAD 54388

For Stainless Steel in ALL Forms—call

Allegheny Ludlum

AL STAINLESS STEEL

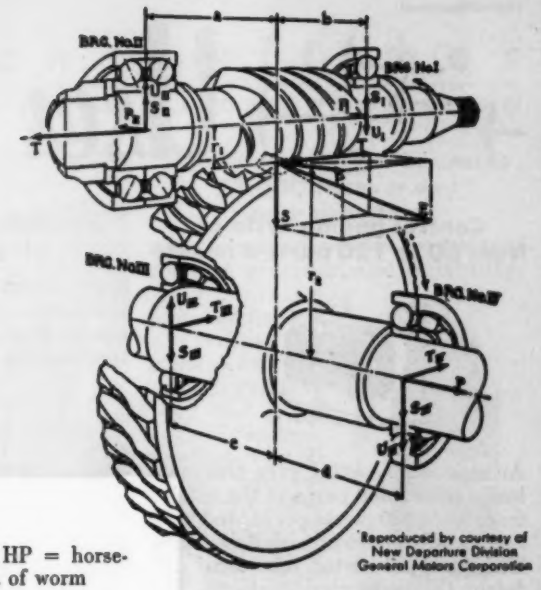
Warehouse stocks carried by all Ryerson Steel plants

—ITEM 581—
For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 582→

Helpful Data from
DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \dfrac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \dfrac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches

[r_2 = Pitch radius of worm gear

$= \dfrac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \dfrac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \dfrac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \dfrac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \dfrac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \dfrac{a}{a+b} = P_I$	$P \dfrac{b}{a+b} = P_{II}$
S	$S \dfrac{a}{a+b} = S_I$	$S \dfrac{b}{a+b} = S_{II}$
T	$T \dfrac{r_1}{a+b} = U_I$	$T \dfrac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$
Due to	on Brg. III	on Brg. IV
P	$P \dfrac{r_2}{c+d} = U_{III}$	$P \dfrac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \dfrac{d}{c+d} = S_{III}$	$S \dfrac{c}{c+d} = S_{IV}$
T	$T \dfrac{d}{c+d} = T_{III}$	$T \dfrac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

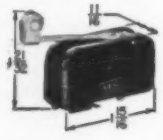
$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

Catalog 5000 contains helpful worm gearing application and specification data. Write on your business letterhead to the De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, N. J.

Uses Unlimited for

Control gaging cycle of from 60 to 120 parts a minute

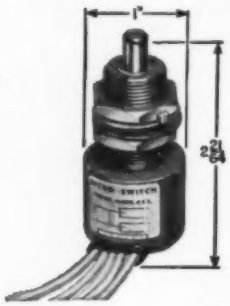


An electronic sorting gage automatically sorts mica parts at the rate of from 60 to 120 pieces per second with help of two MICRO precision switches. The parts are sorted into eight different thickness classifications. The gaging cycle is initiated by the operator who breaks a photoelectric beam with the piece of mica in the hand. The switches are operated by timing cams to control the various steps.

Three factors—extreme precision, accurate repeat operation and long-life dependability—were MICRO SWITCH characteristics that influenced their choice.

6 switches indicate fighter wing flap position

Six of these new cylindrical switch assemblies are used on a military fighter plane to let the pilot know the position of his wing flaps.



The aircraft engineers told us that the MICRO precision switches were chosen because (1) space was very limited (2) the switch was exposed to ice, oil and dust and required an excellent seal and (3) absolute reliability was mandatory.

How a mercury switch adds to your barber shop shave

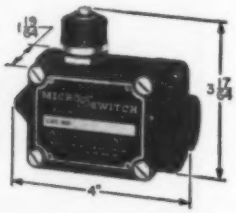
Lather that oozes into your barber's hand from his counter dispenser, does so because of the action of a HONEYWELL Mercury Switch.

Depressing a plunger on top of the dispenser tilts the mercury switch. This starts a motor and the lather is delivered by the turn of a plastic worm screw. The switch fits easily into a streamlined design and is unaffected by the moist environment.

Small HONEYWELL Mercury Switches such as this meet the demands of small load circuits and applications where space and economy are critical factors. They are widely used by designers of animated displays, control and indicating devices, home freezer units, alarms and in hundreds of other tilt motion, low force applications.

Speed operation of Comparators by 50%

Two MICRO precision switches help make the operation of an optical comparator faster, safer and more automatic. Used as upper and lower vertical limit switches, they make it impossible to raise or lower the work table beyond previously adjusted limits.



This process speeds work up to 50% by leaving the operator free to position his work quickly without fear of damage to the machine.

The switches used were chosen because of their quick and dependable response, their sealed plungers to resist entrance of dust or dirt and their convenient mounting and wiring arrangements.

64 Subminiature Switches in Airborne Navigation System

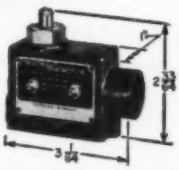
Sixty-four MICRO Subminiature Switches, grouped on a panel which measures but 5¼" wide by 7¾" long, perform important functions in the card reader of an airborne navigation system.

The switches are actuated by holes in punched cards and transfer information from the cards to the computer which gives the information to enable a pilot to fly a selected course.

Engineers chose MICRO Subminiature Switches because they combine unusually small size with the utmost precision and reliability required in such delicately adjusted equipment.

31 MICRO precision switches in automatic riveting press

MICRO SWITCH enclosed switches are used to give foolproof control of the various steps of an hydraulic riveting press. Thirty one switches control the ten automatic operations by which a plate is riveted to an aircraft crankshaft.

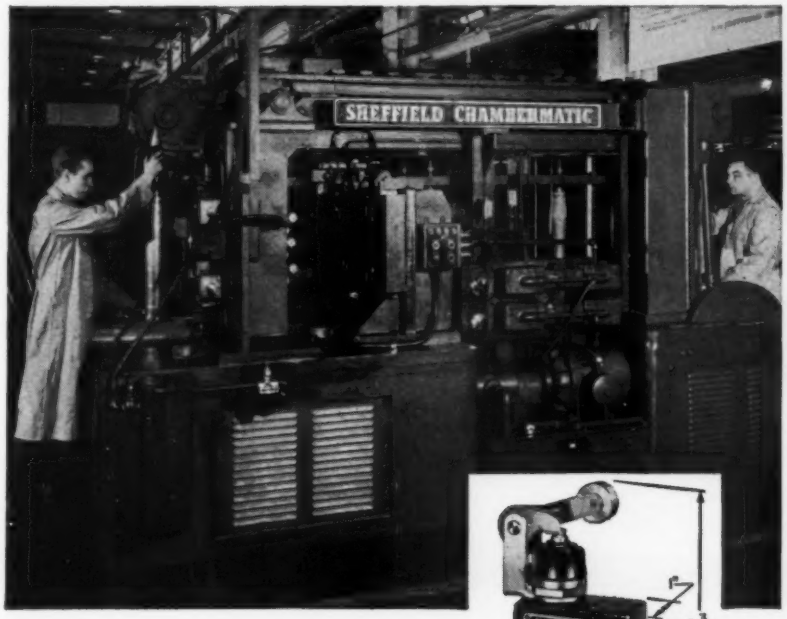


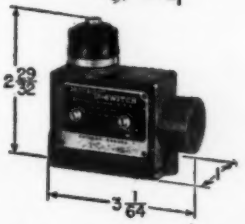
Automatic action of the switches protects press and crankshaft alike against damage caused by misalignment of the part being processed or from carelessness on the part of the operator. It is impossible to operate the press unless parts are properly seated.

The designers chose MICRO SWITCH controls for this highly complex equipment because of their recognized precision, dependability, sturdy construction and long-lived performance.

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN





"Inspects" ammunition rounds—one every four seconds

MICRO precision switches—34 of them—perform key functions in an automatic gage, perhaps the largest ever built. Fully loaded ammunition rounds, weighing 43 pounds, are given final checking for profile and alignment at the rate of one every 4 seconds. The result is increased assurance of uniformity and lower inspection costs.

The switches control each step of the electro-pneumatic gaging cycle, position the shells on the conveyor and stop the machine at any deviation from normal. Engineers chose MICRO SWITCH for:

- **Extreme reliability of performance**
- **Long life dependability of operation**
- **Low actuating force required**
- **Small size with rugged construction.**

Heavy duty switch operates 57,000 times a day with precision

MICRO precision switches are designed for *both* precision and reliability. As precision switches for the control of the steps of an automatic grinder they had to be ruggedly housed, unaffected by oil splash, conveniently mounted and actuated. In addition, they had to be capable of sensitive, high-speed operations—some of them every 1½ seconds, three shifts a day. This means 57,000 precise operations in a 24 hour period, day after day.

Three different types of switch actuation were required—roller arms, rollers and straight plungers. Versatile adjustment of roller arm and roller mechanisms in these MICRO heavy duty switches permitted mounting in minimum space.

Let MICRO SWITCH Engineering Service be your short cut to better design

MICRO SWITCH Engineering Service is made up of experts on just one thing—precision switching problems.

Whatever your design problem, its solution may easily be expedited by consultation with an engineering service that has helped in the solution of many complex electrical switching problems.

MICRO SWITCH may have already solved a problem similar to yours—for somebody else. Should your problem turn out to be entirely new, MICRO SWITCH can—and will—develop the switch you need.

Send for new Catalog 83 on industrial enclosed switches.

MICRO SWITCH Engineering Service is available to help you select the exact switch or switches suited to your requirements. Branch offices are located in key cities.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

—ITEM 583—
For More Information Circle Item Number on Yellow Card—page 19

NOSCO "CAN DO"

Other injection molders said..."Impossible"

We took a second look

It was a complex air-conditioning grille—no question about that. But impossible? —our ingenious engineers didn't think so. We helped with the plastic-part design . . . developed a special molding material . . . designed a mold with almost 90 feet of parting line . . . then built the mold. We molded the several plastic parts on our modern pre-plasticized presses, inspected, decorated, and conveyor-line assembled. Nosco packed and palletized the finished parts according to our customer's needs—shipped the initial desired quantity as scheduled, and the rest were stored in the warehouse section of our 227,000 sq. ft. plant, awaiting releases.

Not every job we do is an "impossible" one. But Nosco "Can Do" can make any plastics problem seem easier. We've proved it over and over again. Let Nosco prove it to you on your next plastic part.

For other case histories—and a glimpse of the Nosco plant and facilities, send for the free 12 page brochure: "How the Nosco Plant Works To Produce Your Needs In Practical Plastics."

Nosco Plastics, Inc.
Erie 2, Pa.
Please send me ( ) copies of the Nosco Brochure.

Name:_____

Title:_____

Address:_____

Firm:_____

NOSCO plastics, inc. • erie 2, pa.

World's largest injection molding plant

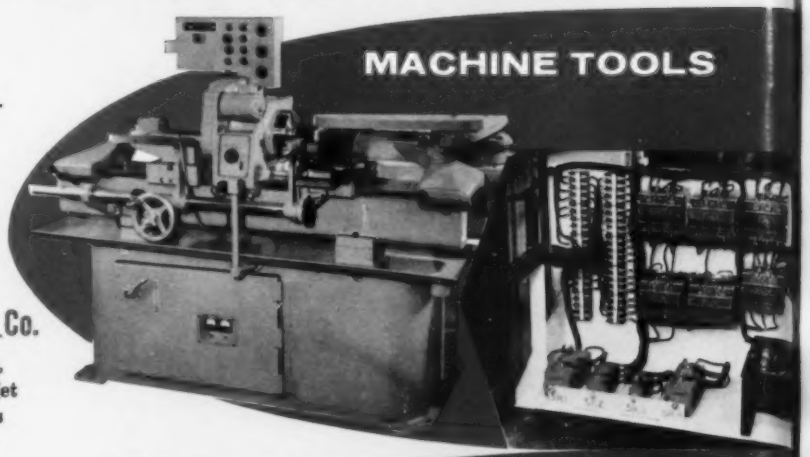
XUM

The Leaders look to ARROW AH HART *Advance Design*

MOTOR CONTROLS

. . . FOR SPACE-SAVING COMPACTNESS

. . . FOR PERFORMANCE-BUILDING DEPENDABILITY

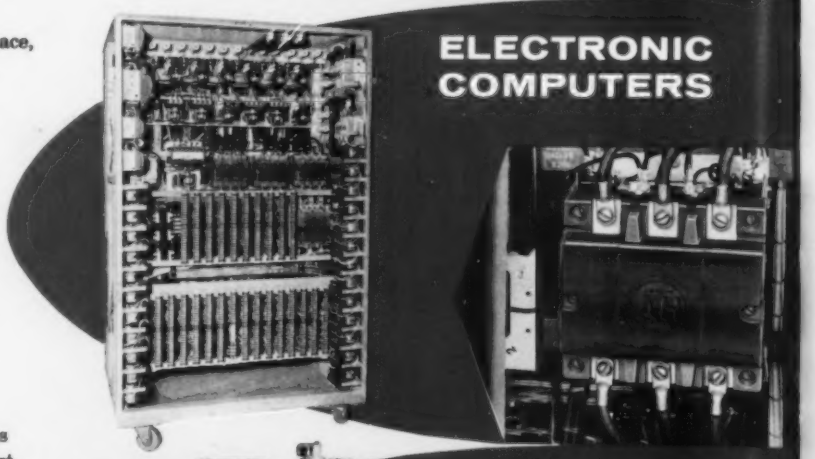


MODEL 102 AIRFOIL MILLING MACHINE

MANUFACTURED BY

The New England Machine & Tool Co.

This ingenious machine mills the original, 3-dimensional masters from which turbo jet blades are manufactured . . . does in hours a job once requiring weeks of hand work. Complexity of the operating and control mechanisms placed a high premium on space, but the 5 smaller, lighter A-H Magnetic Controls were easily mounted on an unusually compact door-back panel that swings out for instant accessibility.



TYPE 704 ELECTRONIC DATA PROCESSING MACHINE

MANUFACTURED BY

International Business Machines CORPORATION

These electronic machines are designed primarily for the use of engineers and research scientists. They are capable of performing more than 4000 multiplications or divisions per second. The 10 Arrow-Hart Contactors included in the very complicated power distribution unit were a natural choice to save valuable space. Other A-H Controls are also utilized in other parts of the machine.

HEV-E-OIL BURNER

MANUFACTURED BY

Cleaver-Brooks Company

Simple, compact and efficient, this modern unit uses low cost, high heat heavy oils to provide economical heat for commercial and industrial buildings. Arrow-Hart Control – an "RA" Starter and a Miniature Relay – occupies little space in the small panel, leaves ample space for easy wiring.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION
Please send my copy of the A-H Motor Control Application folder. MD

name _____
position _____
company _____
co. address _____
city _____ zone _____ state _____

ARROW AH HART

ARROW-HART

MOTOR CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
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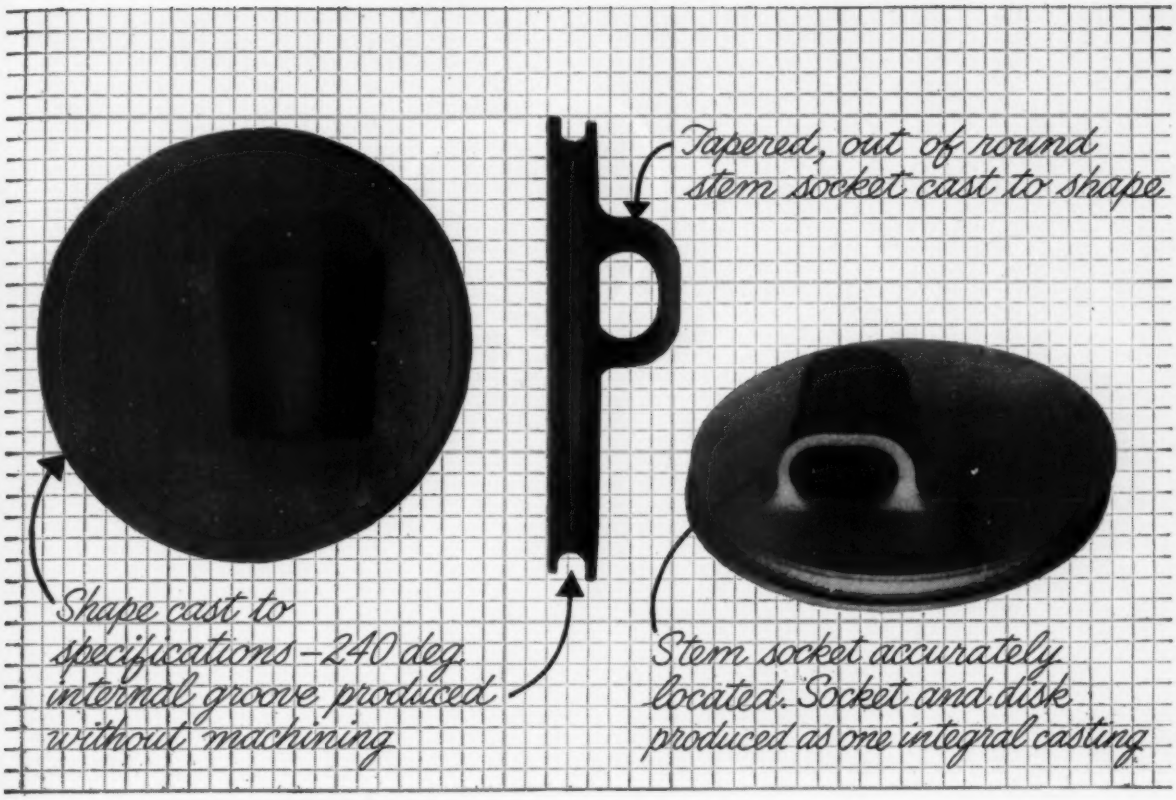
Offices, Sales Engineers and Warehouses in Principal Cities

Quality MOTOR CONTROLS • WIRING DEVICES
ENCLOSED SWITCHES • APPLIANCE SWITCHES

MAIL COUPON TODAY FOR COMPLETE INFORMATION



Investment-Cast in One Piece . . . 5 Secondary Operations Avoided

This intricate valve disk and stem socket were investment cast at a considerable saving in machining, assembling, and joining costs. The disk is produced in an odd shape and has a concave rim with a 240-degree groove. There is a tapered, out-of-round recess in the stem socket. The disk and socket were designed and produced as one integral casting.

The shape of the disk, vital to the proper functioning of the part, was cast to size. A contour machining operation would have been required to produce this shape by other methods. The groove in the rim of the disk, and the stem socket, were also cast to size . . . thus eliminating two more difficult machining operations.

An assembly operation, which would have required precision locating devices, was also avoided. The stem socket had to be accurately located . . . 0.225 in. from the centerline of the disk. This location was held to within plus or minus 0.005 in. on the finished part by the investment-casting method.

Reducing production costs by eliminating secondary operations is only one of the many advantages of HAYNES' precision-investment-casting process. For the full story call or write to any of the District Sales Offices listed below:

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

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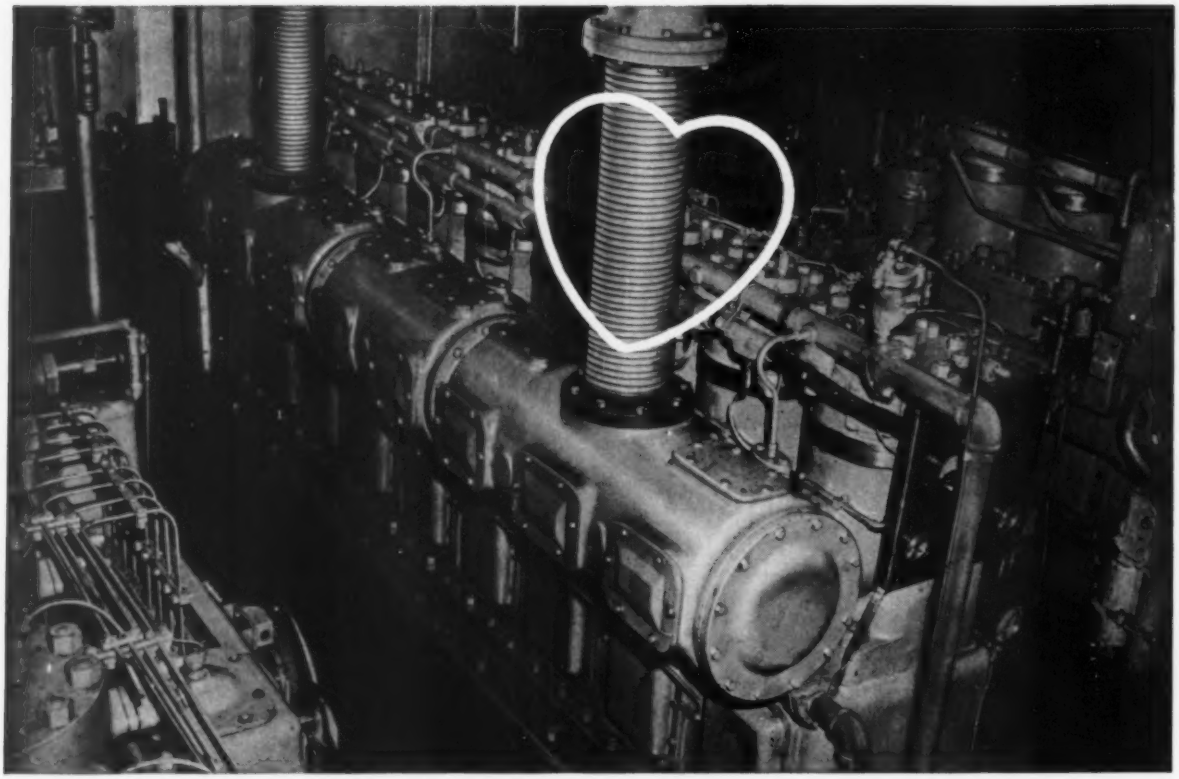


GIVES HORSEPOWER THE *P-U-R-R* OF A KITTEN

Flexible tubing reduces Diesel vibrations... Absorbs thermal expansion

Ever been around while a smoothly-running Diesel warmed up . . . and then, in a few minutes, began a series of vibrations? It's a condition often traced to the type of piping used on air intake and exhaust lines.

Such vibrations can be prevented . . . or cured . . . with Penflex four-wall interlocked tubing, which is flexible enough to absorb the vibration . . . tight enough to prevent any leakage of air and gases. It has other important features, too . . . it "gives"—instead of breaking with thermal expansion.

Afloat or ashore, Penflex tubing finds many applications on Diesel engines . . . on exhausts and air intakes . . . fuel oil and starting air lines . . . lubricating oil and water circulating lines . . . as a partial listing.

Penflex makes a complete line of four-wall, interlocking and seamless welded corrugated tubing, including braided-wire or rubber covered types . . . ⅛" to 24" I.D., in materials suited to various conditions.

"Flexineering," the science of selecting the tubing of the right size, weight, type and construction for these numerous applications, will be explained to you by Penflex engineers. Or you will find our "Flexineering" booklet both helpful and interesting. Send for your copy today.

Pennsylvania Flexible Metallic Tubing Company, Inc., 7239 Powers Lane, Philadelphia 42, Penna. • *Branch Sales Offices:* Boston New York • Chicago • Houston • Cleveland and Distributors in Principal Cities

flexineering by

PENFLEX

HEART OF INDUSTRY'S LIFELINES

FLEXIBLE TUBING, AUTOMATIC BARREL FILLERS, PNEUMATIC RIVET PASSERS, ACCESSORIES AND FITTINGS

—ITEM 587—

For More Information Circle Item Number on Yellow Card—page 19

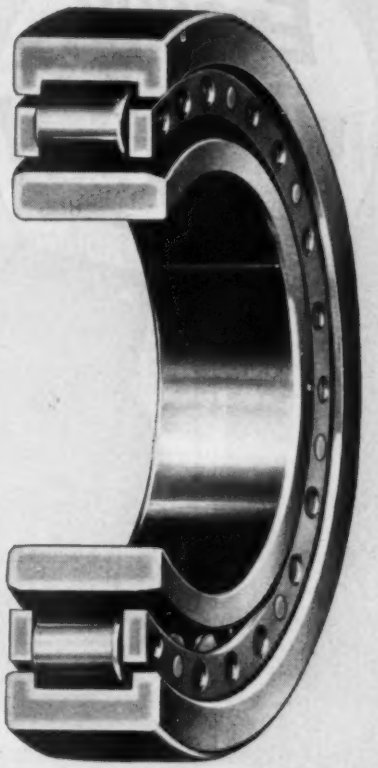
No job too little . . . or none too tough for BOWER STRAIGHT ROLLER BEARINGS

A complete line, a wide range of sizes to fit your specific needs

Square pegs weren't made for round holes. And aircraft bearings aren't built for farm equipment, either. That's why Bower designs a complete line of straight roller bearings—a line broad enough to meet any product requirement.

Jet planes break the sound barrier . . . need bearings that'll keep pace. So Bower aircraft bearings are engineered with exactness and precision to tolerances held to millionths of an inch. Bower tractor bearings, on the other hand, are built for ruggedness . . . to take heavy loads and real punishment, day after day, month after month.

Bower Roller Bearings are proved performers *in every field,* for *any* straight roller bearing application. From motors to earthmoving equipment, they're on the job—cutting maintenance and downtime, setting new standards of efficiency and economy. Get details on the *complete* line from a Bower engineer.



Tapered, Straight and Journal Roller Bearings for every field of transportation and industry

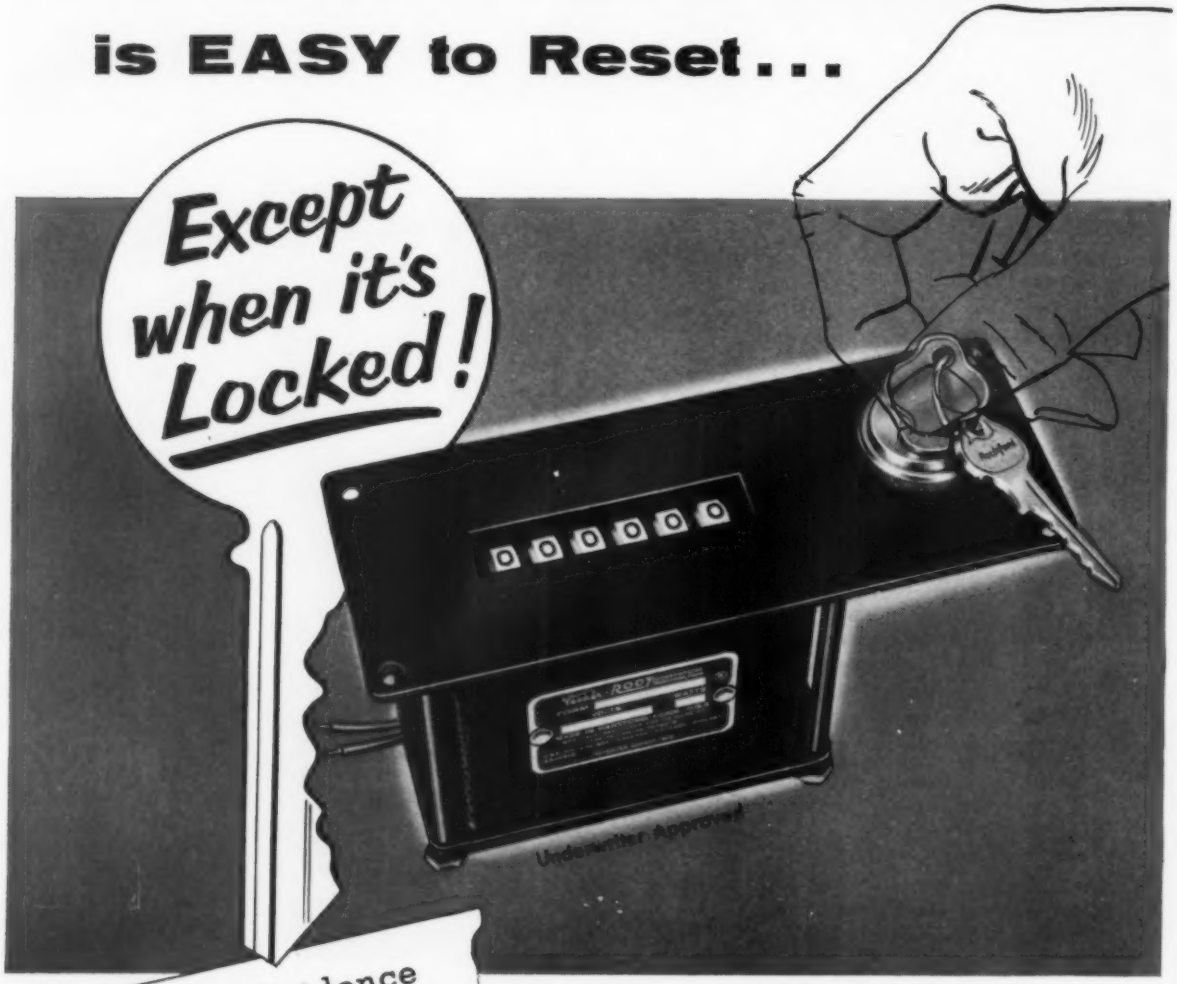
BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION • FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

—ITEM 588—

For More Information Circle Item Number on Yellow Card—page 19

This NEW Magnetic Counter is EASY to Reset...



Added Evidence that—

Everyone Can Count on VEEDER-ROOT

Designed for panel mounting where remote indication is required, this electrically operated counter is a compact package 5.5″ long, 2.1″ wide, 2.7″ high. Capacity: 1,000 counts per minute. Power consumption, 8 watts. Stocked in 110 and 220 AC and DC. Easy to reset, except when locked . . . then the sturdy tumbler-lock* puts the damper on tampering. Yet one turn of the key resets all 6 figures to zeros.

This new Magnetic Counter is one of the thousands of Veeder-Root standard and special counters . . . electrically, mechanically and manually operated . . . in daily use throughout the world in industry, business, science and medicine. You, too, can count on Veeder-Root . . . to help you count anything you need.

*National Lock Co. Lock No. 68-4837; Key D-428

Stocked at
Hartford 2, Conn. • New York 19, N. Y.
Greenville, S. C. • Chicago 6, Ill.
Montreal 2, Canada
Offices and Agents in Principal Cities

VEEDER-ROOT
"THE NAME THAT COUNTS"

—ITEM 589—
For More Information Circle Item Number on Yellow Card—page 19

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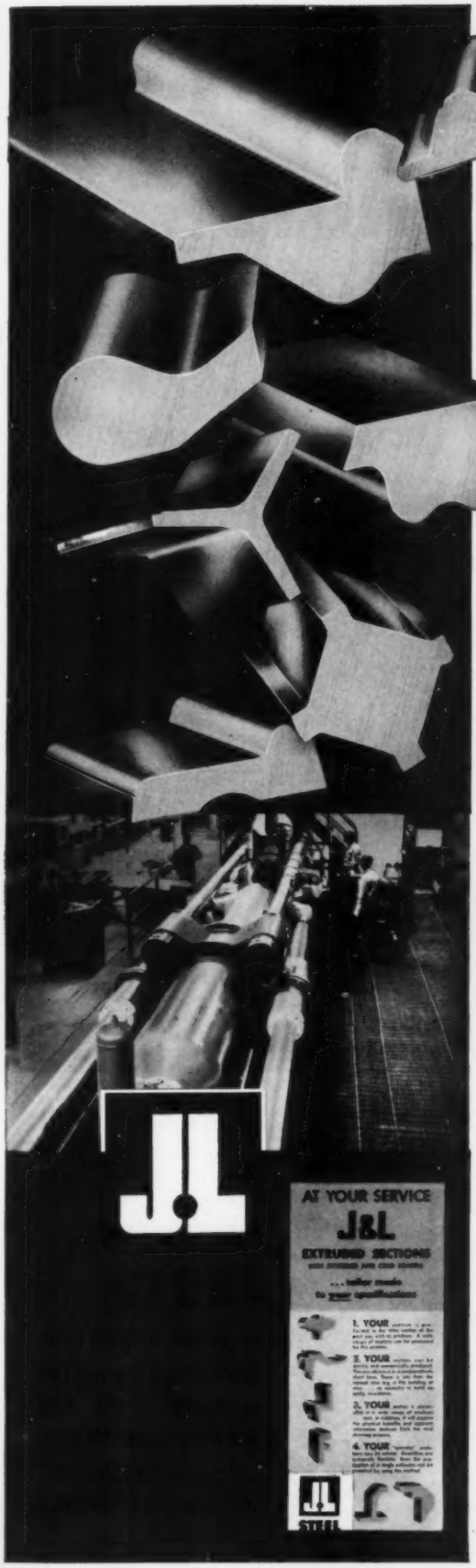


J&L CUSTOM-MADE HOT EXTRUDED COLD DRAWN SECTIONS

...boost production, cut over-all costs

Progressive industry is today utilizing J&L's Custom-Made, Hot Extruded Cold Drawn Steel Sections to:

1. **Eliminate time and costs** in machining and finishing operations
2. **Reduce scrap losses** practically to the zero point
3. **Eliminate the cost of castings and forgings** of intricate sections requiring considerable machining
4. **Reduce inventories** due to their quick availability from the J&L plant

These sections can be extruded and cold drawn to the exact specifications of the parts you require—in any quantity you specify. Even the production of a single extrusion can be economical. Obtainable in a wide range of analyses, J&L Extruded Sections can be produced in a large variety of shape profiles—even many of those that cannot be hot-rolled are practical.

The physical benefits of J&L Extruded Sections are equal to or greater than those derived from the cold drawing process, and tolerances are as accurately maintained. The excellent surfaces of these Extruded Sections require little—if any—finishing operations.

Send us your inquiry for prompt and efficient J&L service.

Jones & Laughlin
STEEL CORPORATION · PITTSBURGH

Jones & Laughlin Steel Corporation
3 Gateway Center, Dept. 410
Pittsburgh 30, Pa.

Please send me your new Booklet on *Extruded Sections.*

NAME_____

TITLE_____

COMPANY_____

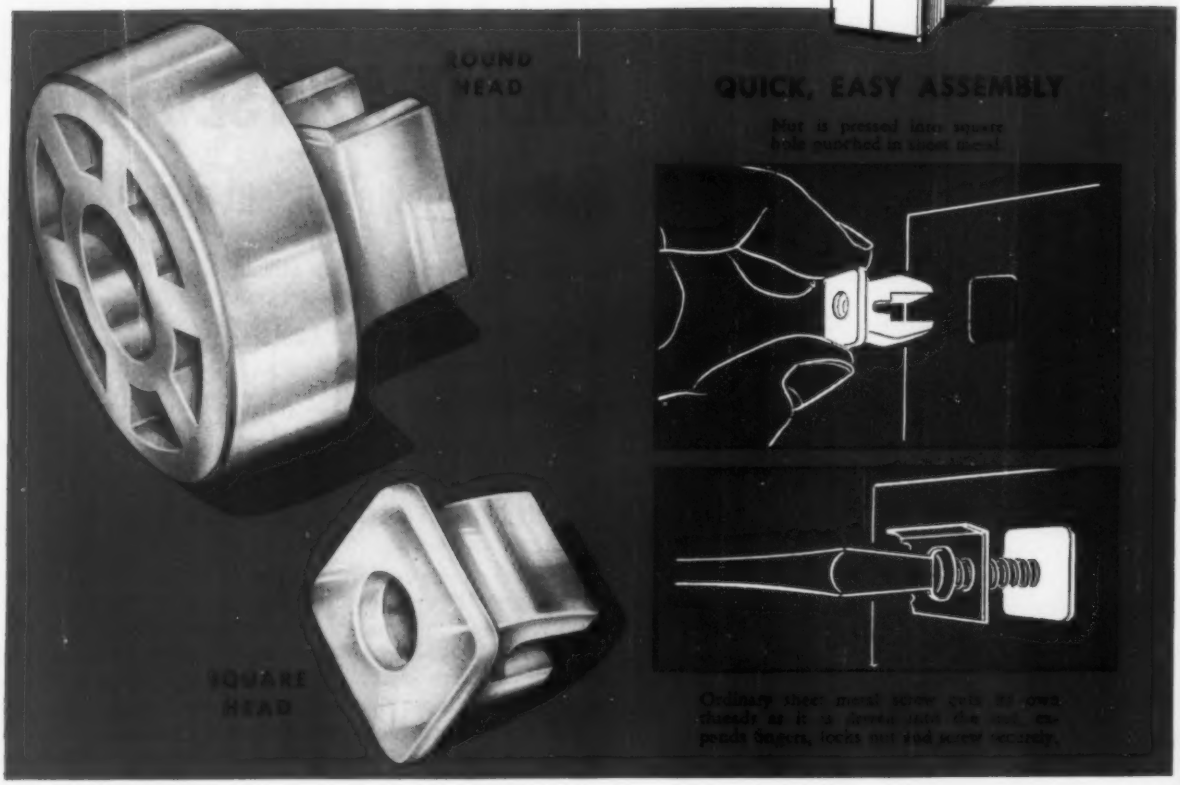
STREET_____

CITY_____ ZONE____ STATE_____

—ITEM 590—

How many ways can **you** use

DOT PLASTIC *snap in* NUTS?



United-Carr's new self-locking, plastic nut is designed for blind application and can be used with all types of metal finishes without scratching or chipping the surface. Its plastic fingers provide rigid anchorage yet will not mar paint, polished metals or even porcelain.

Inexpensive sheet metal screws cut their own threads and expand the nut's fingers as they are driven, locking both nut and screw tightly in place. Screws can be removed and replaced several times without damage to the nut.

DOT plastic snap-in nuts are electrically non-conductive and provide a high degree of insulation against heat transfer. For all practical purposes, they also provide an effective vapor seal.

Available in several styles and sizes. Write for full information and samples or contact your nearest United-Carr representative.

UNITED-CARR FASTENER CORP.

CAMBRIDGE 42, MASSACHUSETTS

MAKERS OF DOT FASTENERS

—ITEM 591—

For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 592→

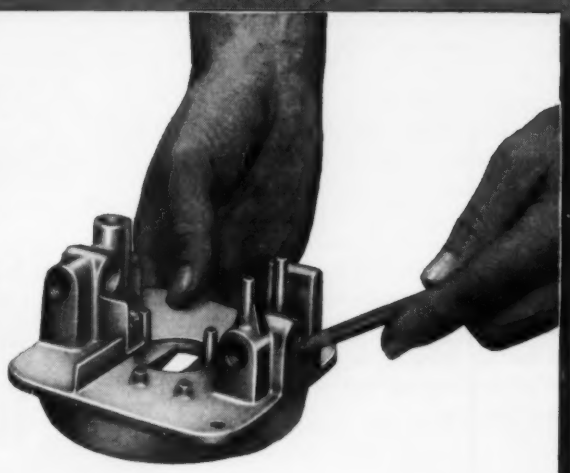
45 years OF SERVICE TO INDUSTRY

It may *look* complex . . . but you couldn't prove it by the cost!

Making this die casting wasn't particularly tricky. But making it in quantity at a low cost *was*. And Stewart did it by devising a setup that performed 24 separate machining operations at one time.

Just one more example of the way Stewart's long die casting experience, plus complete machining facilities, have helped industry.

If *you* have need for a die casting, remember, you can always count on Stewart to meet your most rigid specifications . . . on time.



This emblem is your assurance that the zinc alloy used in every Stewart die casting meets the rigid specifications established by the American Die Casting Institute.

STEWART SW WARNER

Stewart DIE CASTING

A DIVISION OF STEWART-WARNER CORPORATION

Chicago, Illinois: 4535 Fullerton Avenue
Bridgeport, Connecticut: 275 Warren Street

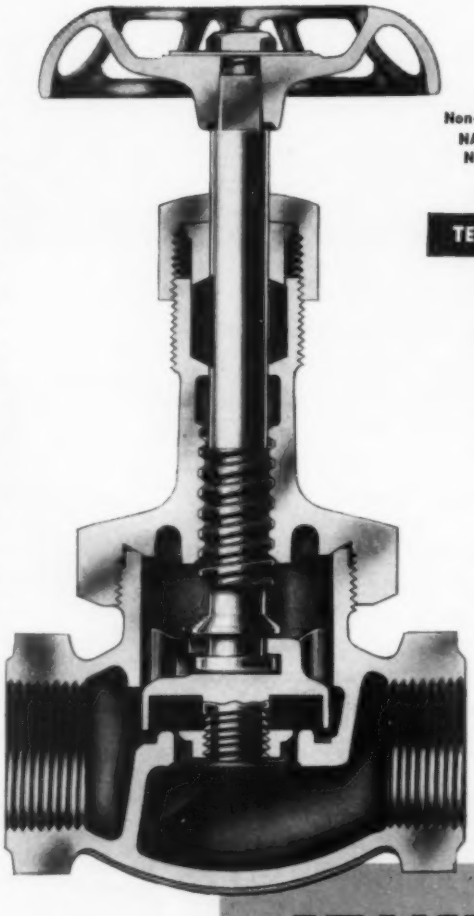
These "Hospital Valves" for **OXYGEN** now serve many industrial needs . . .

JENKINS Bronze Globe and Angle with **TEFLON** disc and packing

Jenkins Figs. 504 and 505 Bronze Globe and Angle Hospital Valves were designed for the critical requirements of controlling oxygen, nitrous oxide, or any non-flammable gases in hospital services. Industry was quick to note the unique advantages, and they are frequently specified for systems carrying gaseous fluids for heating, cooling, lighting, and processing, where pressure does not exceed 400 psi, or temperature a maximum of 150° F.

Fitted and tested to comply fully with all Association specifications for hospital services, they have the "extra value" construction throughout that is assured by Jenkins quality standards.

Get details—find out how these valves can improve efficiency and economy in your hookups for critical service. They are another example of the broad range of "valves for every service" in Jenkins' complete line.



Complies fully with "Standards for Non-Flammable Medical Gas Systems" of—
NATIONAL FIRE PROTECTION ASSOCIATION
NATIONAL BOARD OF FIRE UNDERWRITERS
AMERICAN HOSPITAL ASSOCIATION

TEFLON Disc and Packing

DuPont "Teflon" is a tough, "waxy" inert solid, gray-white in color, tasteless and odorless, non-adhesive and frictionless. Teflon's high resilience assures perfect contact of disc with lapped, crowned seat for gastight closure. Packing is one-piece ring of Teflon, provides dependable leak-proof seal with light compression.

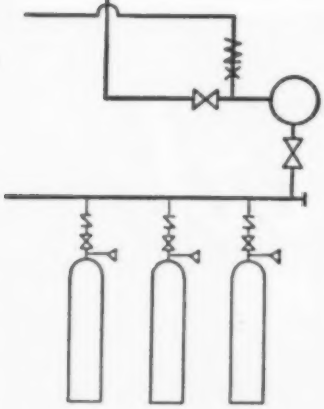
Reinforced Body Casting
High strength bronze body is ribbed along bottom centerline providing extremely high factor of safety. Guards against distortion from vibration, shock, or pipe strains.

Degreased
All bronze parts are thoroughly degreased before assembly.

Polished Spindle
Alloy bronze spindle is polished to permit easy turning and assure leak-proof seal.

Patterns
Globe Fig. 504, Angle Fig. 505

Sizes and Pressure
¼" to 2" 400 lb. O.W.G.



GET COMPLETE INFORMATION from your Jenkins Valve Distributor, or write: Jenkins Bros., 100 Park Ave., New York 17. Ask for Bulletin 116.

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
SINCE 1864 TRADE JENKINS MARK
Jenkins Bros.

SOLD THROUGH LEADING INDUSTRIAL DISTRIBUTORS EVERYWHERE

—ITEM 593—
For More Information Circle Item Number on Yellow Card—page 19

New DynAC® stops motors *instantly*...without a ripple!

Here's dramatic proof of the smooth, controlled braking action of the new Westinghouse DYNAC braking controller. Motor stopped *instantly*—without disturbing the water in the glass goblet. "Grabbing" or jerky stops are eliminated with DYNAC braking.

Wherever rapid and/or controlled stopping is required, DYNAC can not only contribute an important safety factor, but it can save you headaches—*and money*—on: (1) production time, (2) material rejects and spoilage, and (3) maintenance expense.

Because it's *completely* electrical, DYNAC requires no mechanical apparatus or motor linkage—it simplifies maintenance. And it comes in *one* compact, spacesaving enclosure. Get the facts on DYNAC's many cost-cutting applications—with every type of standard induction motor. Use the coupon below for more information on DYNAC. J-30200

YOU CAN BE SURE...IF IT'S

Westinghouse

WESTINGHOUSE ELECTRIC CORPORATION
P.O. Box 868, Pittsburgh 30, Pa.

Please send me descriptive bulletins 15-600 and B-6572 on the new DYNAC braking controller.

Name_____

Company_____

Address_____

City_____ State_____

—ITEM 594—

CALL ON R/M ENGINEERING SERVICE

TWO EXAMPLES OF THE THOROUGHNESS OF R/M PACKING ENGINEERING

Top-flight design engineering combined with superior molding techniques makes R/M Vee-Flex Rings and R/M Fabric Piston Cups ideal for hydraulic and pneumatic applications. And they're typical of the quality you can expect from R/M.

R/M VEE-FLEX is America's most copied packing. It's designed for every piston and rod and has proper interference for automatic sealing—even at pressures in excess of 6000 psi. Its other outstanding features are polymer saturated fabric; precision trimming; and rock-hard adapters to prevent extrusion, resist high pressures.

R/M FABRIC PISTON CUPS meet all your requirements. Accurate, carefully controlled molding assures dimensional uniformity and therefore maximum sealing effectiveness. Deeper, more thorough penetration of the compound into the fabric keeps wicking action from destroying the cup internally and resists ply delamination. These cups are thoroughly inspected, their hardness is consistent, and they adhere strictly to industry standard sizes.

The complete R/M line includes packings and gasket sheets for use against air, gas, water, steam, oil, chemicals, solvents, and food products. R/M also makes a complete line of asbestos textiles. If you have problems involving any of these materials or products, feel free to call on R/M's specialized engineering service.

For booklet shown, or other data, write, phone or wire:

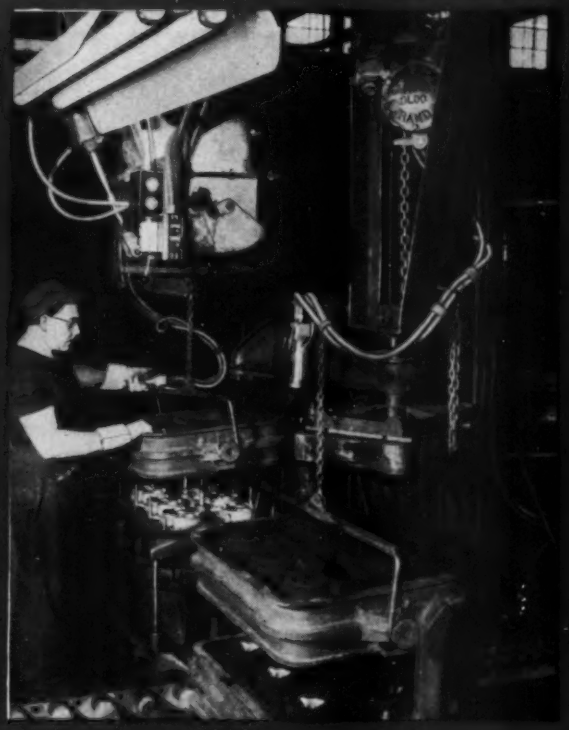
PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J. • GRegory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa. • Manheim 5-2211

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings | Fan Belts and Radiator Hose | Mechanical Packings and Gaskets | Abrasive and Diamond Wheels | Industrial Drive Belts | Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS



ENGINEERED RUBBER HOSE

If your design calls for rubber hose, R/M has a superior construction to meet your specifications . . . or R/M will custom-engineer one that does—whether to resist acid, oil, heat, or of non-spark, non-contaminating construction. New Allflex Hose is ideal for handling air, water, oil, gases and mild chemicals . . . it's the *first* horizontal braided, mandrel-made hose for all-purpose use. Burst-proof Super-Master BW Steam and Air Hose with special flexible wire-braid reinforcement for rugged, high pressure service. Light Homoflex Hose with rope-like flexibility for air tools and water. Condor Flexible Rubber Pipe with Hydro-Lok flanges to replace metal pipe for wear and corrosion. General use or special purpose . . . you get design advantages of rugged strength plus maximum flexibility and light weight when you specify R/M hose. Whether it's hose, transmission or conveyor belts, V-belts, Poly-V® Drives or molded rubber products—you can depend on R/M.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

WOVEN OR MOLDED Friction Parts

As the developer of the first asbestos brake lining, Raybestos-Manhattan has always been first in friction. Where asbestos will best meet your friction requirements, R/M experience can determine precisely whether woven or molded asbestos parts, or a combination, will give you better performance. Where metal or any other materials are needed, remember that R/M offers the widest range of friction materials in the industry. Unlike other manufacturers, R/M works with *all* kinds of friction materials, so that you can be sure of completely *unbiased* advice whenever you consult an R/M engineer.

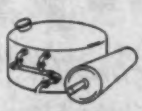
Write, phone or wire for your copy o, R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

Another new development using

B. F. Goodrich Chemical *raw materials*

Hycar blankets manufactured by Haartz-Mason, Inc., Watertown, Mass. Distributed by New England Newspaper Supply Co., Worcester, Mass.

Hycar makes good impression in high-speed printing

WITH thousands of newspapers per hour coming off the press, alignment and pressure on the printing plate must be right during the run. That requirement puts Hycar nitrile rubber in the news.

Blankets made of Hycar fit around the impression cylinder that presses the rolling paper down on the printing surface. The Hycar blanket has to give under the pressure of the curved printing plate, yet snap back to its original thickness and hold it through millions of impressions. Its thickness can't vary more than a thousandth of an inch.

It takes a special rubber to take the destructive action of synthetic inks and oils used in today's printing. The chemical resistance of Hycar rubbers is well known and along with its physical properties it is the answer to the pressman's problem.

One of the Hycar rubbers can be the answer to your materials requirement. For instance, Hycar polyacrylic rubbers will stand dry heat or oil immersion up to 350° F. Hycar nitrile rubbers are highly resistant to aqueous solutions including synthetic detergents. Hycar compounds are far superior to general purpose rubbers in resistance to oxidation and aging. To find out more about these rubbers, please write Dept. EJ-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Hycar American Rubber

GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

—ITEM 596—

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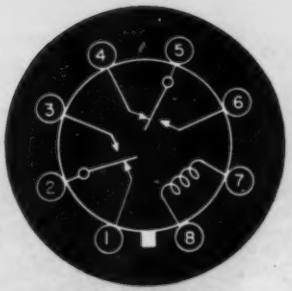
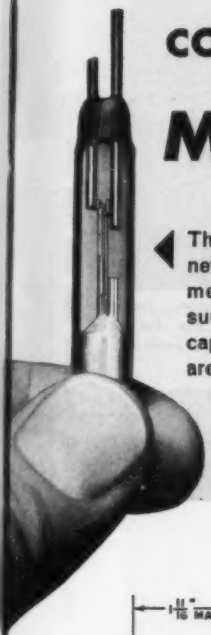
3 NEW CLARE MERCURY-WETTED CONTACT RELAYS TO HANDLE MULTIPLE CIRCUITS

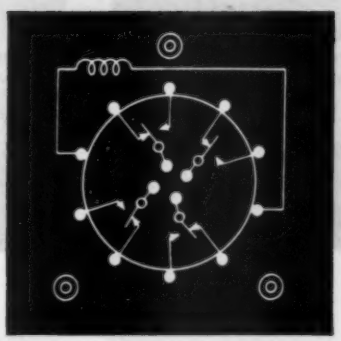


2 FORM C

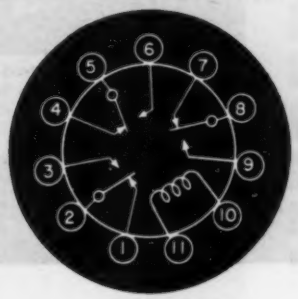
TYPICAL BASE CONNECTION DIAGRAMS



These relays contain 2, 3, or 4 magnetic switches. Each switch is hermetically sealed in a high pressure hydrogen atmosphere in a glass capsule. Platinum contact surfaces are continuously wetted with mercury by capillary connection to mercury reservoir.



4 FORM C



3 FORM C

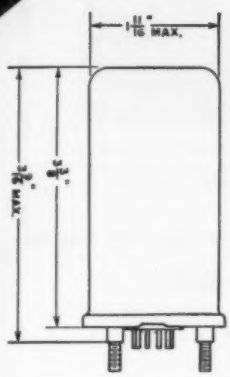


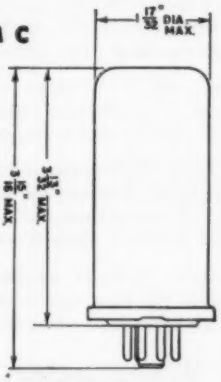
Photo and dimensional drawing of steel can in which 4 Form C switches are enclosed with coil. Plug-in header shown.

SAVE SPACE, MONEY and POWER

In applications requiring more than 1 Form C contact, a multicontact relay may be used instead of 2, 3 or 4 of the standard type HG Mercury-Wetted Contact Relays described in Sales Engineering Bulletin No. 120, thereby saving chassis space, first cost, and operating power.

2 OR 3 FORM C

Photo and dimensional drawing of steel can for either 2 or 3 Form C switches. Octal base plug shown is for 2 Form C. An 11 pin base is standard for 3 Form C. Solder terminals also available.



ELECTRICAL FEATURES

LONG LIFE: Conservative life expectancy of over a billion operations when operated within ratings.

HIGH-SPEED: Give consistent performance at speeds up to 60 operations per second.

HIGH CURRENT—and voltage-handling capacity, up to 5 amperes, up to 500 volts; (250 volt-amperes, max.)

UNIFORMITY: Operating time varies by only about 0.1 millisecond under constant drive conditions.

NO CONTACT BOUNCE

MECHANICAL FEATURES

- Small chassis space required
- Convenient plug-in mounting
- Environment-free
- Tamperproof
- High sensitivity
- Maintenance-free
- No contact wear
- Adjustment cannot change

FOR COMPLETE INFORMATION

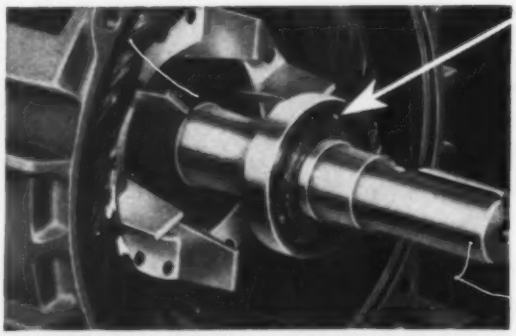
on CLARE Mercury-Wetted Contact Relays for single or multiple circuits contact your nearest CLARE representative or address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois.

Send for CLARE Sales Engineering Bulletin No. 120

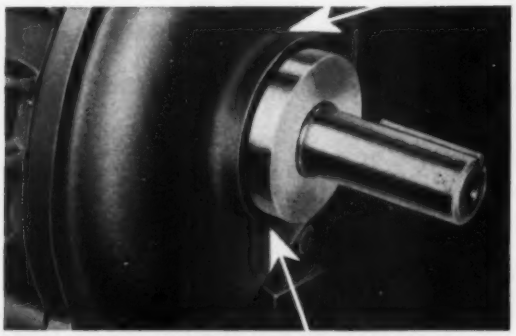
FIRST in the industrial field

CLARE RELAYS

Wagner ELECTRIC MOTORS...the choice of leaders in industry

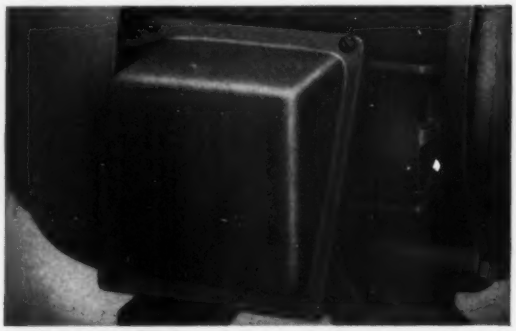


HEAVY-DUTY BALL BEARINGS—Highest quality bearings of more than ample capacity to carry heavy loads provide long trouble-free service.



BEARINGS CAN BE RE-LUBRICATED—These Wagner motors can be re-lubricated when necessary to prolong bearing life. New grease can be added—old grease removed through openings provided in top and bottom of bearing housing.

BEARINGS STAY CLEAN—Both ends of these motors are equipped with running shaft seals to keep dirt, dust and water from the bearings. There's no grease loss because bearing housings have effective seals to prevent escape of grease.



EASY TO CONNECT—Large diagonally-split conduit box which can be mounted in any of four convenient positions, provides ample room for making connections. Leads are readily identified by numbers stamped on the terminal bushing.

Wagner totally-enclosed motors mean less down-time for machine tools

New NEMA Frames Standard and Explosion-Proof

Wagner totally-enclosed fan-cooled motors are particularly suitable for use on all types of machine tools.

They are fully protected against damage from steel filings, chips, dust, dirt, fumes and moisture. They require no maintenance other than periodic lubrication.

If appearance is a factor, you'll find that the pleasing proportions of these motors give them that functional beauty obtained only when the design is fundamentally *right*.

Ribs on the corrosion-resistant cast iron frames add mechanical strength and increase the surface area for more efficient cooling. Full information and principal dimensions are given in Bulletin MU-203 which is yours for the asking.

Your nearby Wagner engineer can help you select the right motor for your applications. Call the nearest of our 32 branch offices, or write us.

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

M36-7

Visit our Booth 437, DESIGN ENGINEERING SHOW, Philadelphia, May 14-17

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Using

DU PONT ELASTOMERS

NEOPRENE · HYPALON®

in Design

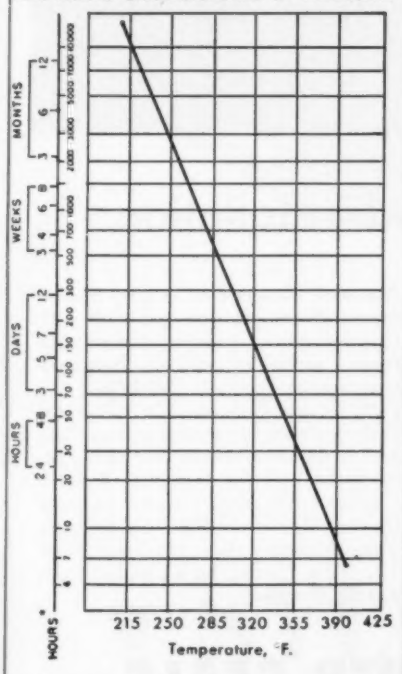
HYPALON® products have exceptional heat resistance

Compared to other kinds of rubber, HYPALON shows unusual resistance to hardening at elevated temperatures (250°-350°F.). This means an extra-long service life for HYPALON belts, hose, gaskets and other products which are used where heat is a problem.

The graph below is indicative of HYPALON's heat-aging characteristics. It shows, for example, that HYPALON compounds will retain 100% elongation after three weeks' *continuous* exposure at 285°F., three months at 250°F. and almost a year at 212°F. Longer service life naturally can be expected where temperatures are intermittent, or where air cannot get at the product—in a gasket, for example.

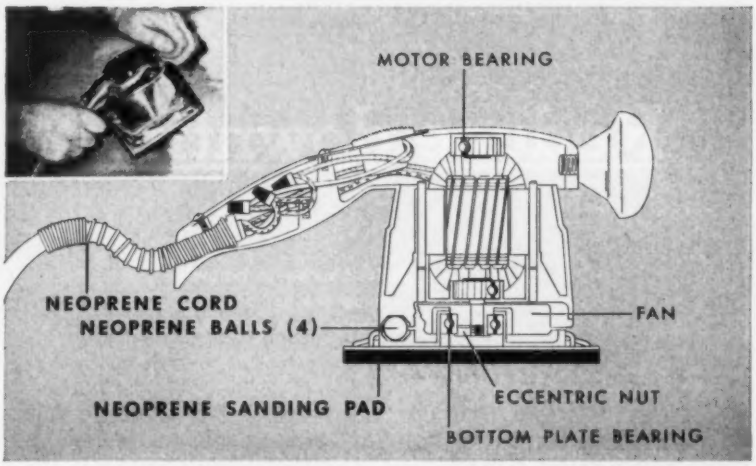
Other advantages of HYPALON include outstanding resistance to weather and oxidizing chemicals, *complete* resistance to ozone and the ability to be compounded in a wide range of light-fast colors.

HEAT AGING CHARACTERISTICS OF HYPALON®



*Exposure time in which elongation dropped to 100%.

Over 200,000 sanders in service—and manufacturer has yet to replace one NEOPRENE part



Low-cost neoprene ball bearings last life of sander... resist abrasion, solvents

Since 1950, a manufacturer of sanders has sold 200,000 units—each with a neoprene sanding disk and a system of neoprene ball bearings. Not one of these neoprene parts has required replacement in that time.

Ingenious use of neoprene

The sander's design is shown above. An eccentric nut attached to the motor shaft imparts a circular motion to the plate that holds the sanding pad. Between this plate and the motor housing are four ½" neoprene balls—one at each corner and each confined in a cavity of 19/32".

These neoprene balls transmit vertical force from the sander to the surface being sanded. They also act as roller bearings as the sander revolves. Finally, thanks to neoprene's resilience, they serve as shock absorbers—minimizing noise and vibration.

Neoprene beats competitors

The manufacturer tested many materials for the balls. Steel balls were noisy and wore out quickly. Natural-rubber balls deteriorated within three weeks when exposed to paint solvents in wet sanding. In the same tests, however, neoprene resisted abrasion and solvents for nearly a year.

Basing his judgment on these tests, the manufacturer chose neoprene not only for the bearing balls but also for the pad to which the abrasive paper is attached. And as a further improvement, neoprene-jacketed cord was also adopted.

DU PONT
REG. U.S. PAT. OFF.

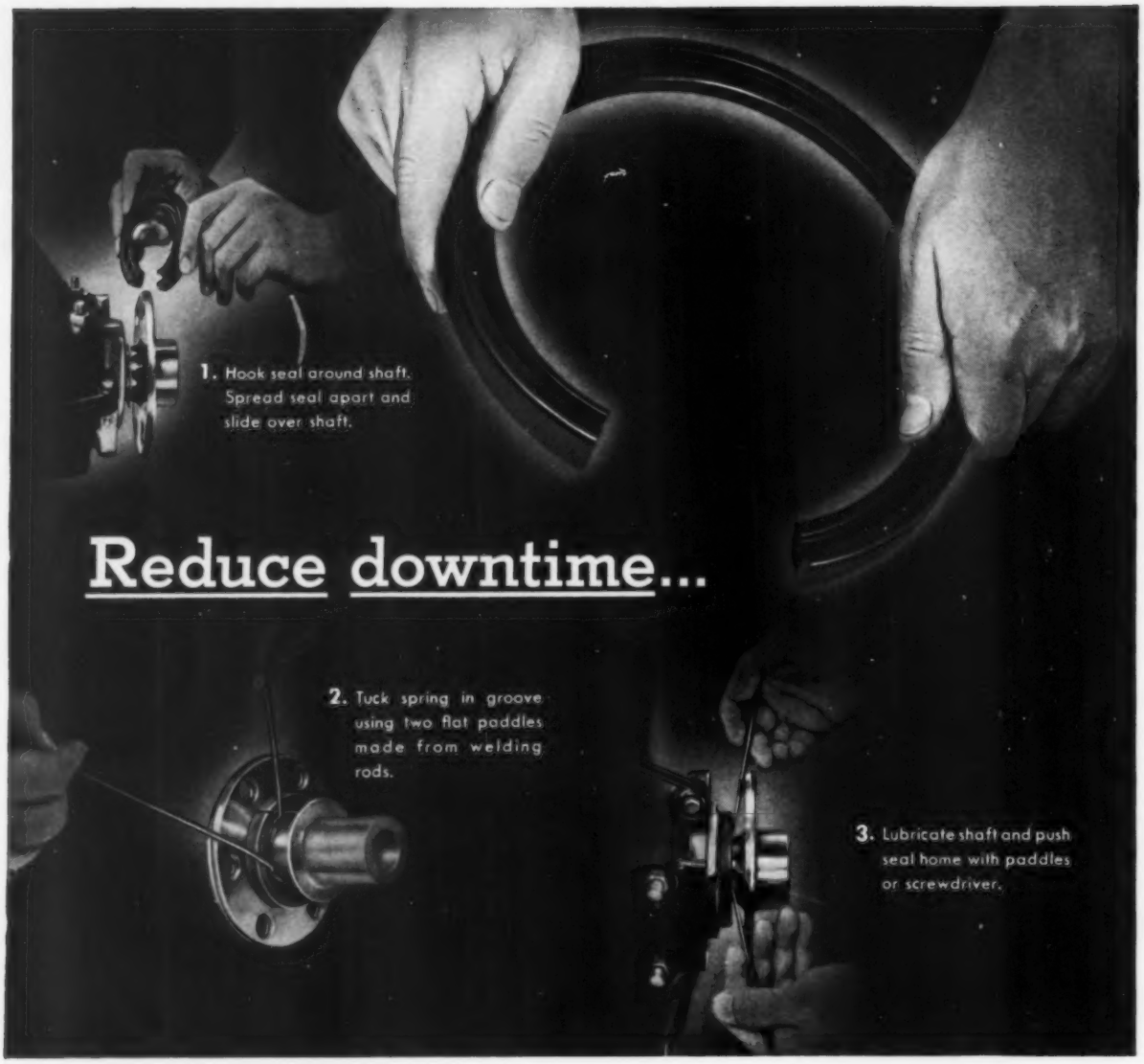
HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further literature and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-4
Wilmington 98, Delaware

Name _____ **Position** _____
Firm _____
Address _____
City _____ **State** _____



How J-M Split Clipper Seals speed installation

. . . flexible body provides easy installation and removal even with small clearances

"Downtime" is measured in seconds when Clipper Seals do your sealing. Furnished in split form and made from a highly flexible synthetic rubber compound, they can be readily slipped into the tightest spots. Neither special training nor special tools are required . . . no drilling and tapping for cover plates is necessary because cover plates are not needed.

Clipper Seals are virtually fracture-proof and stand up well under rough handling by inexperienced mechanics. The self-adjusting garter spring has a hook and eye which is easily hooked around the shaft. It is then a simple procedure to slip it into the groove. When the shaft end is accessible, solid seals are used and snap into place almost as quickly as you can say "Clipper Seal." What's more, they stay put.

Reduced "downtime" is only one of many advantages you get with J-M Clipper Seals. Precision moulded from a variety of corrosion-resistant compounds specially developed for each service, they provide maximum sealing ability, low torque, long life and wide adaptability. For more information on the complete line of Clipper Seals, write for new 28-page illustrated brochure PK-71A. Address Johns-Manville, Box 60, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville CLIPPER SEALS**

—ITEM 600—

How to reach the equivalent of

4 suppliers in one call

for—

1. precision metal stampings and wire forms
2. custom-molded plastic parts in thermoplastic and thermosetting materials
3. custom plated, clad, or alloyed, cold-drawn wire in sizes from .250 to .002
4. electronic components designed to meet the latest needs of equipment designers

Most products include parts which call for one or more of the services above. Some products call for all of them. And all of these facilities are available to you in Sylvania's unique four-way service to designers. One call brings them to your door promptly.

Sylvania's Parts Division Representative serves as your complete parts and wire consultant. He is experienced in applying the benefits of completely modern and automatic equipment to your particular problems.

And he knows design problems straight through from drawings to deliveries. He's your liaison to Sylvania's complete staff of designers, engineers, production specialists, and tool and die makers.

Why not make that one call that will bring you the equivalent of four suppliers? Call your nearest Sylvania Parts Representative. He's listed in Sweets Catalog Service. Write for the "portfolio of 4-way service to designers."

PARTS DIVISION

metal stamping | special wire | molded plastic | electronic parts

Sylvania invites you to call on the Parts Division for consultation at any time without obligation

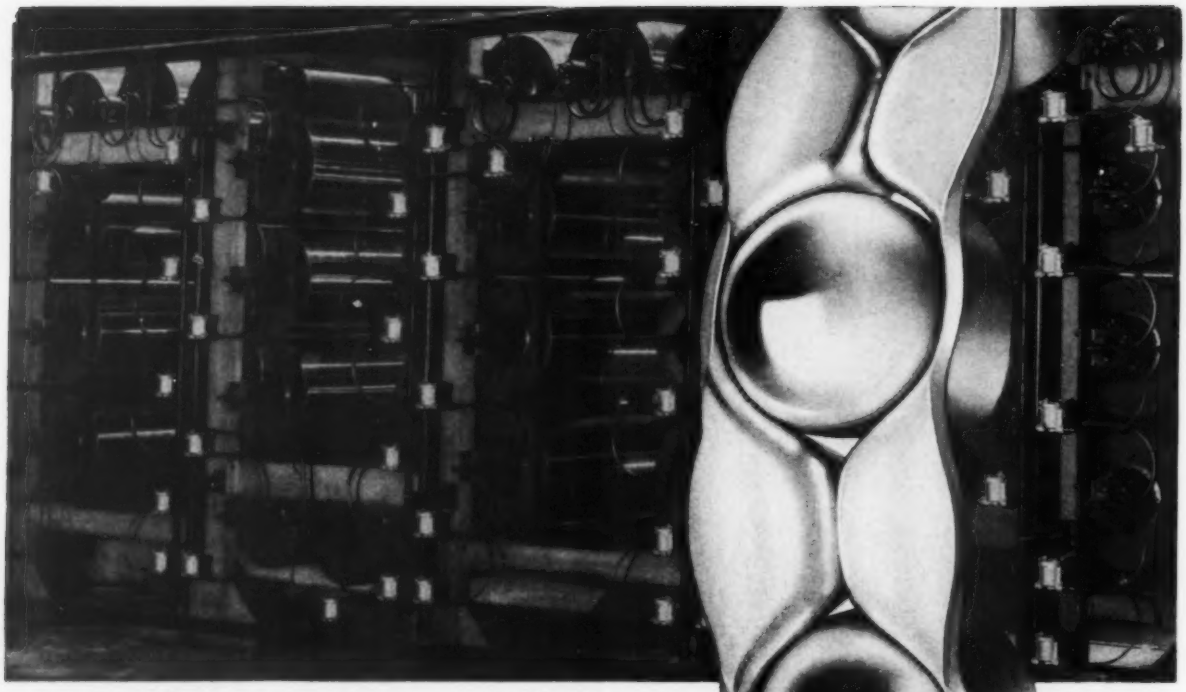
SYLVANIA®

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd.
University Tower Bldg., Montreal

LIGHTING • RADIO • TELEVISION • ELECTRONICS • ATOMIC ENERGY

—ITEM 601—

For More Information Circle Item Number on Yellow Card—page 19



SEALMASTER'S (PATENTED) BALL RETAINER

- **Stops "Churning" of grease!**
- **Assures equal load distribution!**
- **Minimizes Ball and Retainer wear!**

"Churning," caused by failure of a retainer to keep grease confined within the ball path of a bearing is another problem that has been eliminated by a SEALMASTER patented engineering feature!

SEALMASTER's patented Ball Retainer features a special flange construction which projects from the outer dimensions of the retainer. This flanged lip confines grease—minimizing centrifugal action. The retainer floats on the ground inner surface of the outer race, eliminating excessive wear of balls and retainer. Accurate spacing of balls assures effective distribution of radial and thrust loads.

This is just one of SEALMASTER's exclusive combination of features you will want on the products you build or buy.

Only SEALMASTER offers you these patented features!

Flange design of retainer traps grease—eliminates "churning," assuring proper lubrication of balls.

Land ridden retainer floats on ground inner surface of outer race—minimizing ball and retainer wear.

Patented centrifugal, felt-lined flinger sealing principle keeps lubricant in, dirt and dust out.

WRITE FOR FULL INFORMATION

SEALMASTER

BALL BEARING UNITS

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVENUE, AURORA, ILLINOIS

—ITEM 602—

For More Information Circle Item Number on Yellow Card—page 19

XUM

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS

Accuracy of Delicate Instruments Assured by Silicone Damping Fluids

With remarkably flat viscosity-temperature slopes, Dow Corning 200 Fluids show little change in damping force over extremely wide temperature spans. That's why these silicone fluids are specified for damping vibrations in instruments ranging from the simplest automobile dash board gauges up to the delicate oil well tools made by Halliburton Oil Well Cementing Co., Houston, Texas.

By retaining a practically consistent viscosity from room temperature to bottom-hole temperatures ranging up to 400 F, 200 Fluid helps to keep Halliburton's drift-angle and direction-survey tool accurate within half a degree at angles up to 13°.

"Direction" of the drilling string is shown by a compass with a highly polished "north" arm suspended in a glass-bottomed plastic case filled with a low viscosity silicone fluid.

"Drift inclination" is indicated by the positions and relative angle between two other polished arms which swing freely within a second glass-bottomed case filled with a high viscosity Dow Corning 200 Silicone Fluid.

The two cases are mounted in the tool with their glass windows facing one another. A pair of photoelectric cells located between them is geared and wired to constantly scan and record changes in both dials while the tool is being lowered into the well. *No. 76*

Silastic, the Dow Corning silicone rubber, keeps its shape, stays resilient from —100 to 500 F; resists hot oils and chemicals; withstands weathering ozone and corona; and is an ideal dielectric material. Properties of Silastic are fully detailed in new reference brochure. *No. 77*

Increase Minimum Bearing Life from 3 to 36 Months

Efficient design, long life and customer satisfaction may depend on solving a high temperature lubricating problem. Here's how such a problem in metal tempering furnaces made by A. F. Holden Co. of Detroit was solved with Dow Corning 44 Grease.

Molten salt is used as the heat transfer medium in Holden's metal tempering furnaces. Maintained at temperatures from 300 to 700 F, the molten salt is circulated by a pump submerged in the bath. The vertical shaft pump is driven by an electric motor located above the bath.

The efficiency of this design was originally discounted, however, by higher maintenance costs due to the melting of even the best organic greases and failure of the journal bearings supporting the pump shaft after as little as 3 months of service. Each bearing failure resulted in three or four hours of downtime and lost production.

Three and one-half years ago, Holden started using Dow Corning 44 Grease. There hasn't been a bearing failure reported since, and customer satisfaction is high. A tube of 44 Silicone Grease is now included with every furnace shipped. To assure its use, Holden has replaced conventional bearing fittings with grease cups. These cups are filled once every two weeks. They are given one complete turn each day.

Continuous performance is further assured by using electrical insulating materials made with Dow Corning silicones to protect the ¾ hp, 1250 rpm pump motor against the high ambient temperatures involved in mounting it close to the pump shaft. Holden's engineers figure that the additional insulating cost of about $12 is negligible compared with reliability and freedom from downtime and replacement costs. *No. 78*

Silicone Finish Adds Color and Life to Space Heaters

Many manufacturers of domestic space heaters have adopted silicone finishes. Available in a wide range of decorator colors, these heat resistant silicone finishes bridge the gap between organic finishes which rapidly lose their attractiveness at elevated temperatures, and more costly porcelain coatings. Here's a report received from one manufacturer of space heaters, the Quaker Mfg. Co. Division of the Florence Stove Co.

"There has been a trend in our design of heaters toward enhancing appearance by finishing certain functional parts in colors contrasting or blending with the greater portion of the cabinet.

"To do this, it has been necessary to use a finish which will be satisfactory in colors formerly considered impractical.

"Silicone paints were the answer to decorative color where high temperatures are involved. This is illustrated by the top grille on the unvented wall heater, the radiant door liners on the oil heaters, and the front grille on our Model 4210.

"Midland Industrial Finishes, a leading formulator of silicone-based paints and enamels, worked with Quaker in solving the finishing problem." *No. 79*

Design Edition 19

DOW CORNING CORPORATION - Dept. 6804
Midland, Michigan

Please send me 76 77 78 79

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ___ STATE _____

ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEW YORK • WASHINGTON, D. C. (Silver Spring, Md.)

Canada: Dow Corning Silicones Ltd., Toronto; **Great Britain:** Midland Silicones Ltd., London; **France:** St. Gobain, Paris

? ? 6 sizes in 2

Rivett Model 6655 Solenoid Controlled, Pilot Operated, Panel Mounted, Hydraulic Valve.

of course!

Rivett Panel Valves
feature interchangeable sizes

By changing pipe tap size in steel subplate, the 1" basic valve may be used for either ⅜", ½", ¾", or 1" I.P.S.; and the 1½" basic valve for 1¼" and 1½".

CORRECT SIZE IS ALWAYS AVAILABLE

and here's another important feature!
GREATER FLOW CAPACITY

Flow capacities are rated at a higher G.P.M. at less velocity per ft. per sec. For example: the 1" size is rated at 28 G.P.M. at 15 ft. per sec.

The Better You Know Hydraulics—
The Better You Like

12 other good reasons tell why Rivett Hydraulic Solenoid Panel Valves are your best buy! Get the facts in this new catalog. Write today!

RIVETT LATHE & GRINDER, INC.
Dept. MD-4 Brighton 35, Boston, Mass.

RIVETT furnishes a complete power package

AIR AND HYDRAULIC—VALVES, CYLINDERS, POWER UNITS

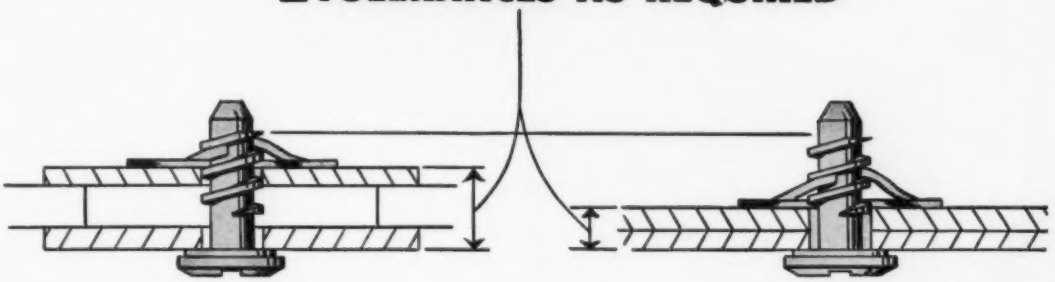
Member—National Fluid Power Association

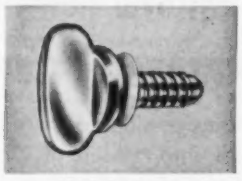
—ITEM 604—
For More Information Circle Item Number on Yellow Card—page 19

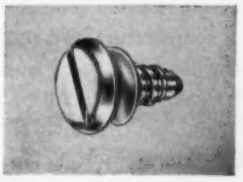
Why change cowl fastener size every time tolerances vary .010" ?

SOUTHCO **quick release fasteners provide:**

±TOLERANCES AS REQUIRED







Industrial tolerances, provided only by Southco Quick-Release Fasteners, are designed to accommodate variations in thickness normally encountered in metal working. No longer is it necessary to call out a different size precision type fastener because of a few thousandths variation. You eliminate a serious stock problem and reduce assembly time when you specify SOUTHCO.

You can easily choose the right Southco Quick-Release Fastener from a wide variety of stock sizes which include two diameters and three head styles.

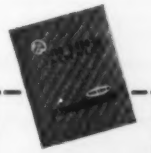
The Southco Handbook makes it easy to pick the proper fastener. Write for your copy today. Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO

FASTENERS

PAWL • SCREW AND SPRING • DRIVE RIVETS • ANCHOR NUTS • ENGINEERED SPECIALTIES

OFFICES IN PRINCIPAL CITIES



SOUTHCO DIVISION
SOUTH CHESTER CORPORATION
237 Industrial Highway, Lester, Pa.

Please send me, without cost, the 24 page SOUTHCO FASTENER HANDBOOK ☐

Please have representative call ☐

NAME _____

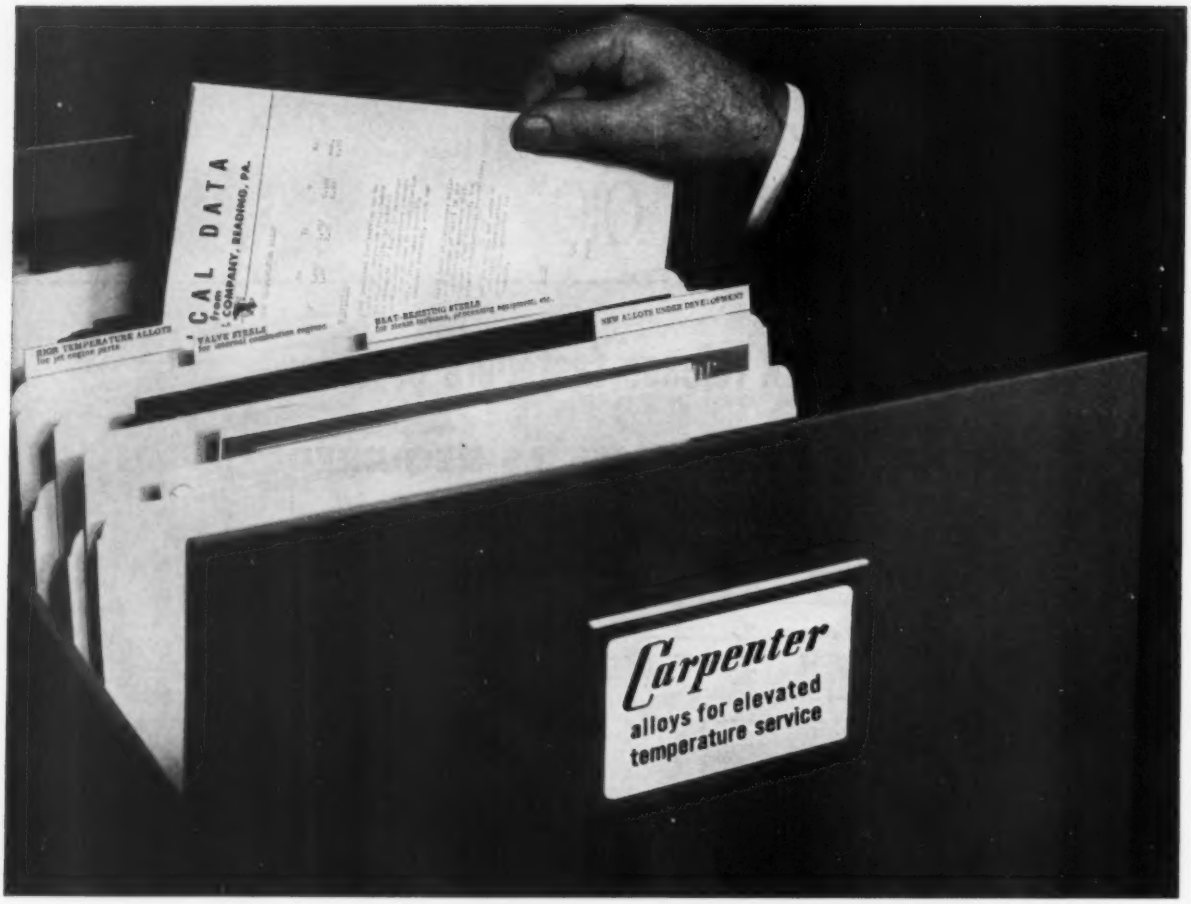
POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

—ITEM 605—



Discover how these ELEVATED TEMPERATURE ALLOYS can give you

√ Improved Forgeability √ Greater Uniformity √ Cleaner Steels

Exciting possibilities for improvement are ahead when you look into the line of Carpenter alloys for parts or products in elevated temperature service. Here is a line of high temperature and heat-resisting alloys produced in a *specialty* mill. Only a true specialty mill can produce so well these very difficult-to-make alloys.

Here, too, is a combination of unusual advantages not normally found in this type of alloys. For example, Carpenter pioneered the addition of rare earth elements to the analyses of certain grades to give you improved forgeability. And Carpenter's unsurpassed, meticulous quality controls, assure you steels with greater uniformity and extra cleanness to meet the strictest inspection requirements.

Whether you work with one of our present elevated temperature alloys, or a steel produced specifically for your own application, you'll find that Carpenter's wealth of fabricating and working information will help you substantially reduce production costs and get better parts.

Outline your plans or problems to your Carpenter Representative or write direct. You'll get the kind of help that pays off with definite improvements. *The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.*

Specify Carpenter alloys for elevated temperature service and get these three big advantages . . .

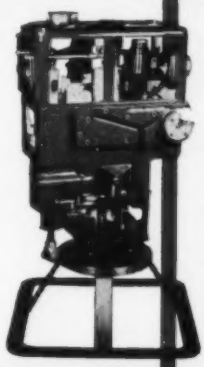
Improved Forgeability
Greater Uniformity
Cleaner Steel

Carpenter STEEL

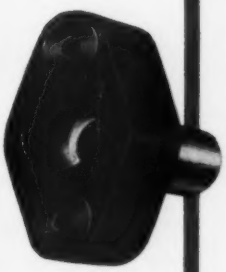
Improved Alloys for Elevated Temperature Service

5 practical ways to "streamline"

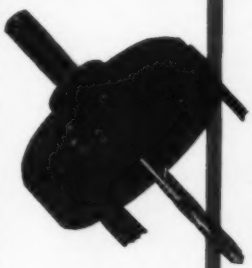
...without sacrificing fastening strength



1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen O Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.



2. Countersinking enables you to get absolutely smooth external surfaces using Allen O Flat Head Cap Screws. Allen O Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen O Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.

4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.

5. Bright finish, or rust and corrosion resistance call for Allen O Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

ALLEN HEAD

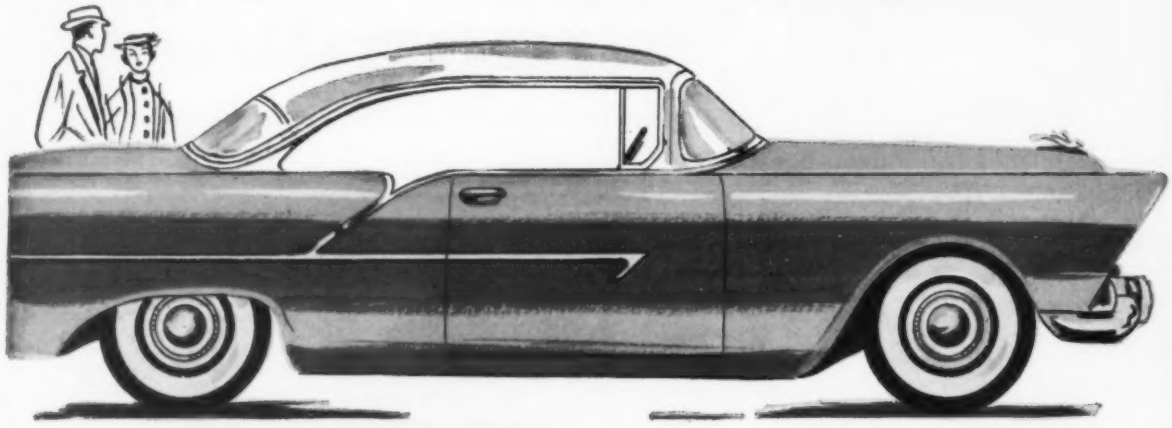
ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.

—ITEM 607—

Tubes of Steel
Help put tires on wheels

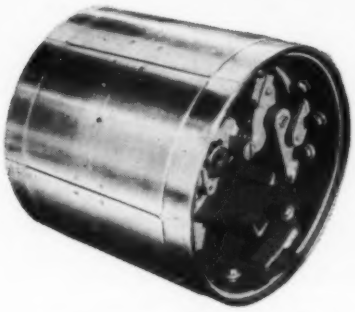


ACIPCO
Centrifugally Spun
STEEL TUBES

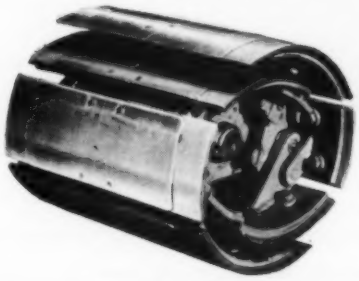
Collapsible steel drums are an integral part of tire building machines manufactured by the Akron Standard Mold Company of Akron, Ohio. These machines are used by almost all major tire companies. The drums shown here, fabricated from ACIPCO centrifugally spun steel tubes, are examples of the excellent machinability which is built into every ACIPCO tube.

In fabricating these drums, Akron Standard first cuts the tube to proper length, then adds the welded components. Next, the tube is sawed lengthwise into sections which can be "collapsed" for easy removal of the completed tire. ACIPCO tubes are especially adapted to this machining operation because of their superior dimensional stability due to lack of stresses.

If your steel tube application demands unusual machinability, a special analysis, an exact diameter or finish, or any other "custom" requirement, find out about ACIPCO centrifugally spun tubes. If you want quality plus economy, get the recommendation of ACIPCO's experienced metallurgists and engineers. You'll find their help is valuable.



6-SECTION PASSENGER TIRE BUILDING DRUM EXPANDED



6-SECTION PASSENGER TIRE BUILDING DRUM COLLAPSED

SIZE RANGE: Lengths up to 16' — longer lengths by welding tubes together. OD's from 2.25" to 50"; wall thicknesses from .25" to 4".

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.

FURNISHED: As cast, rough machined, or finish machined, including honing.

AMERICAN CAST IRON PIPE CO.
ACIPCO
Special Products Division
BIRMINGHAM 2, ALABAMA

DISTRIBUTORS:

Austin-Hastings Co., Inc.
226 Binney St.
Cambridge 42, Mass.

J. M. Tull Metal & Supply Co.
285 Marietta St., N. W.
Atlanta, Ga.

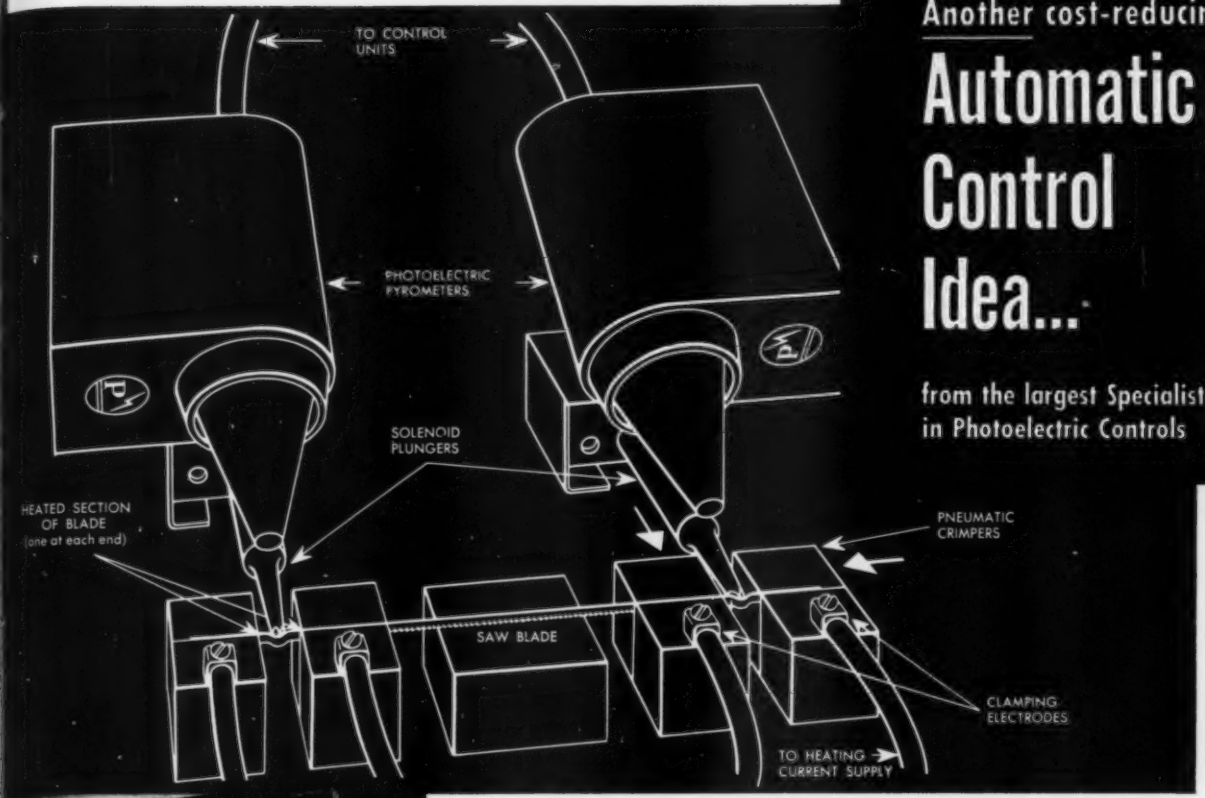
Peter A. Frasse and Co., Inc.
17 Grand St.
New York 13, N. Y.

C. A. Roberts Co.
2401 Twenty-fifth Avenue
Franklin Park, Ill.

Lyman Tube & Bearings, Ltd.
920 Ste. Sophie Lane
Montreal 3, Canada

Strong, Carlisle & Hammond Co.
1392 W. Third St.
Cleveland 13, Ohio

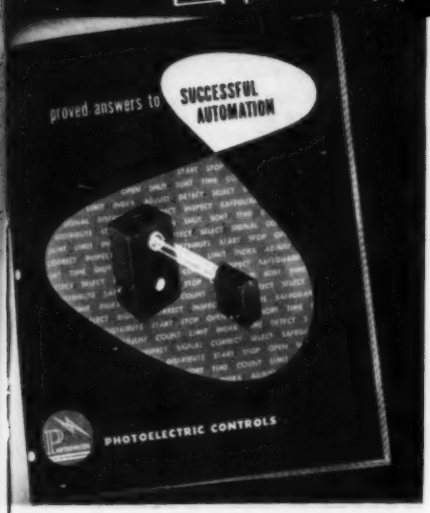
Ducommun Metals & Supply Co.
4890 So. Alameda St.
Los Angeles 54, Calif.



Another cost-reducing

Automatic Control Idea...

from the largest Specialists in Photoelectric Controls



Temperature-Controlled Automatic Forming of Metal Parts

In finishing the narrow blades used in coping saws, each end of the blade is hot-formed into a small loop or "ear" that locks the blade in place on the saw frame. Temperature of the blade ends must be exactly right: too high, and the steel becomes brittle . . . too low, and the loops are difficult to form correctly.

Parker Manufacturing Company, in Worcester, Massachusetts, used two Photoswitch Photoelectric Pyrometers to automate the whole process. The unfinished blade is placed in the forming jig, and an actuating button is pressed. Electrode clamps at each end of the blade press tight, and pass electric current through a small section of the blade itself, so that the tips grow red hot. At exactly the right temperature, each pyrometer automatically trips a plunger mechanism that forms the loop in the metal. The instantaneous response of the pyrometer cuts the heating and forming cycle to less than ¾ of a second.

The results are greatly increased production rate, uniformly high quality, drastic reduction of unit costs, and reliable, self-checking operation that *automatically* takes account of every important variable.

In Photoswitch's wide variety of high quality photoelectric controls, liquid level controls and electronic timers, you will probably find an exact answer to your automation requirements. Write for the helpful new Photoswitch Catalog . . . and if you have a specific problem, tell us about it.

FREE — Important New Catalog

"Proved Answers to Successful Automation" is a brand new 20-page technical catalog, giving full specifications, application information and dimension drawings on 14 versatile Photoswitch Control Sets. You will find it an important reference manual in solving automatic control problems. Use coupon to get your copy.

SEND FOR YOUR COPY NOW

Photoswitch DIVISION
ELECTRONICS CORPORATION OF AMERICA
Dept. P2-4, 77 Broadway • Cambridge 42, Mass.

☐ Send FREE Catalog — "Proved Answers to Successful Automation"
☐ Send FREE Bulletin describing Photoswitch Photoelectric Pyrometer

Name and Title .....
Company .....
Address .....
City ..... **State** .....

FIREYE DIVISION • COMBUSTION CONTROL DIVISION • BUSINESS MACHINES DIVISION
PHOTOCONDUCTOR-TRANSISTOR DIVISION • MARINE DIVISION • MILITARY DIVISION

In addition to the many permanently mounted Moyno pump installations, Realemon has two Moyno pumps mounted on wheels which can be moved to any of the 24 blending tanks. This provides a quick and economical way of blending the juices. The Moyno is self-priming; won't cavitate or vapor-lock. It has no valves to stick, no pistons to gum up. It's trouble-free and built for tough service.

The Moyno pump has had an outstanding performance record for more than 8 years at Realemon-Puritan Company, Chicago, Ill., makers of the famous Realemon beverages. Fruit juice concentrates must be pumped and filtered to blending tanks . . . a task only Moyno pumps can perform to Realemon's satisfaction.

Moyno® Pump exclusive choice of Realemon engineers for pumping juice concentrates

In the preparation of many of the famous Realemon products, concentrated fruit juices often must be pumped and filtered to blending tanks.

Pumps formerly used to handle this exacting process wore out completely in a few months because of their inability to stand up under the high acids in citrus juice concentrates.

Realemon then changed to the Moyno pump. Its unique rotor and stator arrangement forms sealed progressing cavities that move the material and provide positive displacement. For this Realemon application, Moynos with chrome-plated rotors and synthetic rubber stators were selected, to assure trouble-free service and long pump life.

Moyno pumps have now been in operation at Realemon for more than eight years, with an outstanding performance record. The only maintenance required is simply to replace the rotor and stator about once a year.

Moynos regularly handle a wide variety of products that other types of pumps can't handle—products such as potato salad, chow mein, fruit, alkalis, pastes, paints, tar —even cement and plaster.

Perhaps the Moyno will solve your pumping problems, too. Write us today for complete information. Ask for a free copy of Bulletin 30-MD.

ROBBINS & MYERS, INC.
MOYNO PUMP DIVISION

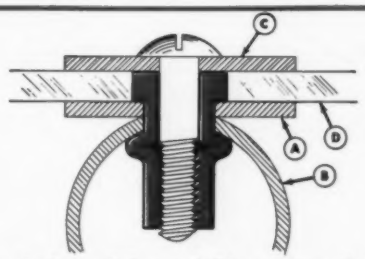
Springfield, Ohio
Brantford, Ontario

—ITEM 610—
For More Information Circle Item Number on Yellow Card—page 19

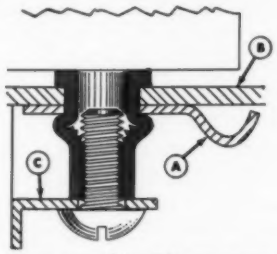
B.F. Goodrich Rivnut

cuts fastening time, saves money by doing two jobs in one operation!

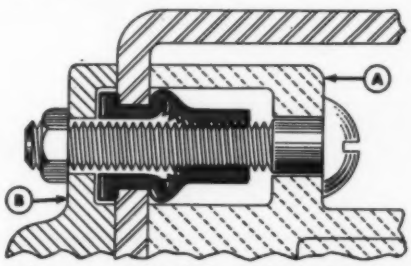
Do you have dual fastening problems like these?



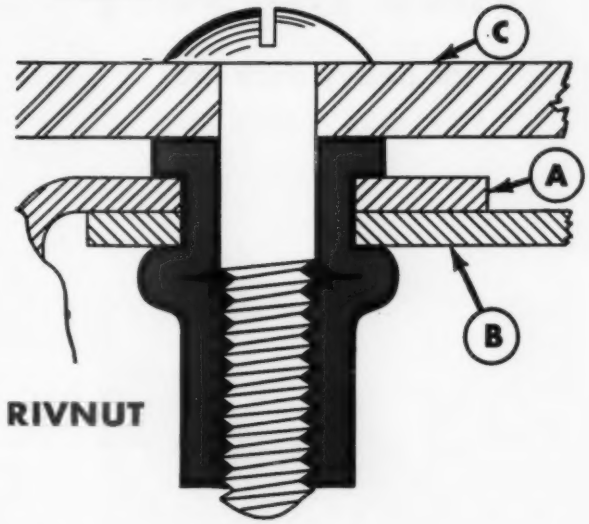
In airplane window seal, Rivnut rivets plate (A) to center post (B), provides nut plate to hold clamp strip (C). Rivnut head serves as spacer for transparent plastic sheets (D). Result: a neat, weather-tight seal!



In vaporizer assembly, Rivnut rivets upper flange (A) to casing (B), makes firm, accurate nut plate for attachment to lower flange (C). Rivnut eliminates reinforcing plate. Result: less assembly time, fewer parts, better product.



Rivnut provides 6-thread 'nut plate for attachment from either end—or *both*. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket (A). Plug base (B) is attached on other side. Result: fewer operations, lower assembly cost.



B. F. GOODRICH RIVNUTS cut costs and speed assembly because they rivet two parts together, make a firm, accurate nut plate for a third. And they do both jobs in one quick operation! Rivnuts can be installed from one side, take an attachment bolt from either end. They eliminate welding, tapping, clinching.

In the transformer assembly above, one worker fastens the metal cover (A) to the plastic sheet (B) with Rivnuts in seconds. Rivnuts then serve as mounting lugs for attaching completed transformer to mounting plate (C).

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs—can do the same for you. Write today to *B. F. Goodrich Company Tire & Equipment Division, Rivnut Sales, Akron, Ohio.*

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Dept. MD-46, Akron, Ohio.

B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads

low-cost "work horse"

for heavy duty jobs

Automatic Electric Class "A" Relays are still "healthy" even after 100,000,000 operations!

Here's a relay built for hard work, and every critical point shows it!

Contact points are formed and life-welded to the spring in one operation. An exclusive armature backstop design prevents armature freezing. A heavy-duty armature bearing is available for unusually heavy spring loads, or constant high-speed use.

Optional "long" or "short" lever armatures offer one lever-ratio for normal operating speeds . . . another for slow-to-release action, permitting a residual gap which holds the required release timing, even under heavy-duty conditions. When extreme conditions suggest added precaution, an armature damper spring may also be supplied to eliminate wear from induced vibration.

For complete details, write for Circular 1800. Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

Originators of the dial telephone • Pioneers in automatic control

GENERAL TELEPHONE SYSTEM

Dimensions

Overall length, 4"—Width, single pile-up 1¼"—double pile-up 1⅞"—Height (depending upon the number of springs), Series AQA and ASO 1⅝"; Series ASR and ASA 1⅛"-2".

Four different types

Of Class "A" Relays are available to meet your needs: Series AQA—Quick-Acting, DC; Series ASO—Slow-Operating, DC; Series ASR—Slow-Releasing, DC; and Series ASA—Slow-Acting, DC.

Contacts

Normally single, but can be supplied with twin contacts. Load carrying capacity, 150 watts (maximum 3 amps., non-inductive).

Contact spring capacity

Can be supplied with single or double pile-ups. Series AQA and ASO, 13 springs per pile-up; Series ASR and ASA, 6 springs per pile-up. (More contacts can be accommodated at a sacrifice of operating speed and release time delay.)

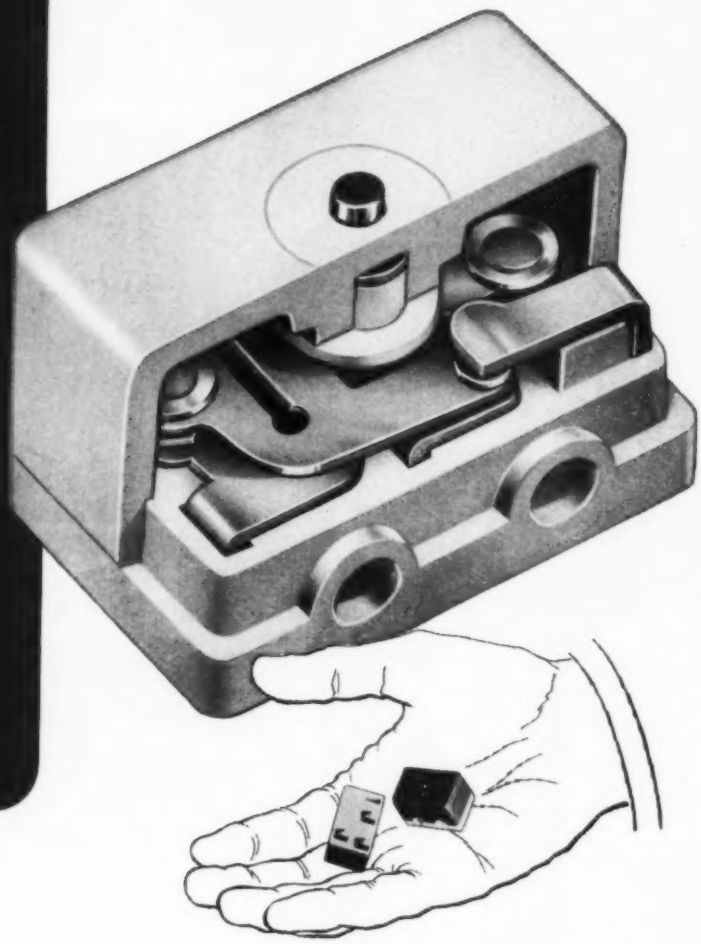
Here it is!

the New KLIXON®

Miniature

Precision Sine Switch

For Aircraft and Industrial Controls, Actuators, Relays, Instruments, etc.



CHECK THESE FEATURES:

- ***Unexcelled Shock and Vibration Resistance*** — precise operation unaffected by 10 G's... vibration from 0-500 cps.
- ***Small Movement Differential*** — less than .001".
- ***High Current Carrying Capacity*** — 10 amperes, 30 VDC and 115 VAC.
- ***Minimum Effect from Ambient Temperature*** — −65° and +275°F operation.
- ***Miniature Size*** — one-half size of comparable units.
- ***Long Life*** — 100,000 cycles minimum.
- Available with a variety of actuators.

This Klixon Sine Switch (J series) is a highly precise, sensitive snap switch for applications requiring extremely small movement differential with high resistance to shock and vibration. Movement differential as well as operating and release forces can be adjusted and set to meet a wide variety of application requirements. Once calibrated, the KLIXON Sine Switch precisely maintains its operating characteristics throughout its life.

Write for Catalogue PR-1100 which gives performance characteristics on the J series and other Klixon Precision Sine Switches.

KLIXON

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
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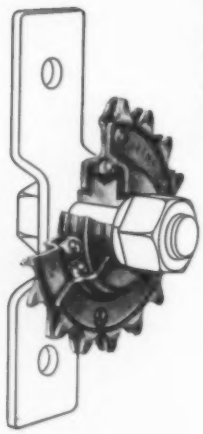
—ITEM 614—

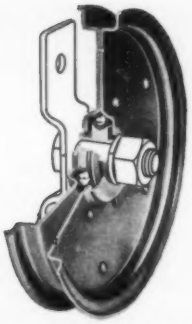
For More Information Circle Item Number on Yellow Card—page 19


Eaton
Permanent Mold
Gray Iron Castings
Meet Critical Quality Requirements
in a Wide Range of Applications
In applications where more than ordinary quality is required, Eaton Permanent Mold Gray Iron Castings provide a number of desirable characteristics:
Dense non-porous structure
Uniform structure throughout the casting
Machinability at higher feeds and speeds
Higher tensile strength
Ability to take high surface finishes
Freedom from leakage under pressure
These qualities particularly recommend Eaton Permanent Mold Gray Iron Castings for such uses as high pressure control mechanisms, refrigeration and air conditioning parts, power steering and power braking components, household appliance parts, and for many other critical applications.
Eaton engineers will be glad to discuss the application of Eaton Permanent Mold Gray Iron Castings to your products.
EATON
FOUNDRY DIVISION
MANUFACTURING COMPANY
VASSAR, MICHIGAN



SPROCKET IDLER UNIT

A sprocket idler and pre-lubricated, sealed, ball bearing—*all-in-one*. Permanently lubricated bearing has full complement of ⅜" balls for greater load capacity, 4-point ball contact for greater rigidity. Sized for ⅝" mounting bolts—teeth-types to fit all standard roller or detachable link chain.



BELT IDLER UNIT

With simple engineering changes this *all-in-one* bearing and idler can be adapted to new designs or current models . . . of combines, balers, harvesters, pickers, elevators, etc. Mounts on ⅝" bolt. Case-hardened sheaves are available with either V or flat belt grooves—in standard section V-belt sizes.

Aetna

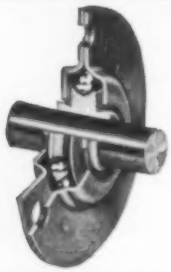
PRE-LUBRICATED BALL BEARING "PACKAGE" UNITS

the low-cost answer for so many drive and conveying jobs

High-quality, low-cost Aetna AG Series bearing units are rugged and dependable; specially designed to meet the loads, speeds and punishing operating conditions imposed by farm implements.

These economy-priced units combine bearing, seals and housing in a single, compact, easy-to-install *package*. They feature *king-size*, factory-packed lubricant chambers; full ball complements and weight-saving, all-in-one housing and outer bearing race construction.

Plan now to change over to these inexpensive units. Adapting them to either your current production models or new designs involves little, if any, engineering alterations. Ask for literature.

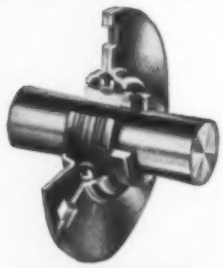


GRAIN DRILL UNIT

This and all other Aetna farm equipment bearing units incorporate *king-size* lubricant chambers, factory-packed with long-life, water resistant lubricant. This feature, combined with Aetna's advanced sealing principle, frees the farmer of troublesome, costly lubrication chores. Can be furnished in ½" or ⅝" shaft sizes.

DISC HARROW UNIT

Here is anti-friction efficiency wrapped in a husky, compact, easy-to-install *package*—job-fitted to rugged farm service. With its exclusive, superior seals; full complement of ⅝" balls and case-hardened races it assures exceptional shock load and life capacity—needs no costly upkeep.



ADAPTER UNIT

An inexpensive multi-purpose unit suited to farm and numerous other equipment applications. Mounts easily, quickly, wherever shafts can be supported—on sheet metal or any semi-rigid structural members. Sealed bearing is self-aligning, has eccentric self-locking collar with set screw. 5 shaft sizes ⅜" to 1¼".

Aetna

1916 40 YEARS 1956 FIGHTING FRICTION

AETNA BALL AND ROLLER BEARING COMPANY

Division of Parkersburg-Aetna Corporation • 4611 Schubert Ave. • Chicago 39, Illinois

—ITEM 616—

MACHINE DESIGN
APRIL 5, 1956

What Price Experience?

SEASONED engineers have reason to view with mixed feelings the spectacular rise in starting salaries for beginning engineers. If this rise were a symptom of a universal shortage of engineers, wouldn't competition have raised the salaries of experienced men in like ratio?

A clue to one answer is revealed in a recent National Science Foundation bulletin. Of 200 employers of research scientists and engineers who were queried, 50 per cent made no point of numerical shortages but reported that their development programs were being hindered by a lack of people with the kind and quality of training needed. The other 50 per cent were experiencing numerical shortages, too.

This suggests that the quality shortage is at least as serious as the quantity shortage. In many areas new techniques of design engineering are demanding a degree of competence — to say nothing of boldness and imagination — which is straining the professional work force beyond its capacity. So high-level jobs are going a begging, despite the availability of many willing candidates.

Faced with this situation, many employers seem to prefer to train new graduates in the necessary skills. Why? On the theory that they will get more years of useful work out of them?

Perhaps there are other reasons. For instance, as J. A. Anderson, general manager of AC Spark Plug division, has pointed out, "Many engineers, after a number of years on a job, become very negative. They feel that they have had a lot of experience, have tried a lot of things and, therefore, can very quickly tell that something will not work. They have become very practical, based on a long career of experience, trial and error."

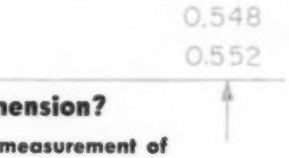
An engineer's ability is measured by his power of attack on new problems. This requires a combination of rigorous training in analysis and synthesis, creative imagination and practical experience. Any man whose "practical" experience has been permitted to overshadow the other qualifications may be no more valuable to his company than the youngster with only academic training which, at least, is fresh and up to date.

With management concentrating attention on the youngsters, the older hand must take the initiative in qualifying for his own advancement. Unless, of course, he is content to be like the school teacher whose principal, in denying him a raise, told him: You haven't had twenty years' experience. All you've had is one year's experience — twenty times.

Colin Carmichael

EDITOR

DIMENSION CONTROL



By Earlwood T. Fortini, *Mechanical Engineer*
Datamatic Corp., Newton Highlands, Mass.

What is a dimension?

A dimension is a measurement of length or angle.

And that's where the problem begins. Every dimension must have a tolerance.

For any kind of interchangeable manufacture, the tolerance must be selected carefully. It must be large enough to allow for expected manufacturing variations, inaccuracies in measurement, and many other variables. Yet it must be small enough to permit the finished assembly to perform properly.

Selecting tolerances for both performance and manufacture is the crux of the matter—and is the subject of this series of articles. The series has one objective: to outline methods for obtaining accuracy by design.

Basically, the methods presented show (1) how to evaluate the function of a mechanical assembly to determine effects of individual component variations, (2) how to analyze geometry of components to locate significant dimensions, and (3) how to control these dimensions by proper tolerancing.

Two techniques of dimensioning are considered: conventional limit or "nonprobability" dimensioning, and probability dimensioning using statistical methods of analysis.

The first two parts of the series outline fundamentals — essentially "what is a tolerance?" Succeeding parts will discuss limit and probability dimensioning. The final article will consider how these methods can be applied in practice—the uses and limitations of dimension control methods.

BROADLY speaking, there are two main uses of dimension control: in design, and in manufacture. *Design* use embraces the study of dimension relationships. Purpose of such a study is to help evolve a geometrically sound design by examining the effects of tolerances on assembly and performance. *Manufacturing* use, on the other hand, is concerned with the problems of making parts and assemblies that meet dimension specifications. Obviously these two aspects of dimension control—design and manufacture—should be closely co-ordinated so that dimension specifications conform to good manufacturing practice.

This series of articles pertains only to the application of dimension control to *design*. Its object is to present general methods for working out dimension problems.

In a general sense, *dimension* refers to a physical quantity such as acceleration, viscosity, stress, conductivity, length, and angle. Measurements of length and angle can be called geometrical dimensions in order to distinguish them as belonging to a particular class of dimensions. Geometrical dimensions are especially important in mechanical design because of their numerous uses. This article is concerned primarily with geometrical dimensions. Unless otherwise indicated, further use of the word *dimension* will imply a geometrical dimension.

If dimensions could be held to exact values, then dimension control would not be a problem. However, every dimension must have tolerance—a difference between maximum and minimum limits big enough to allow for manufacturing variations, measuring inaccuracies, material deformation and other factors, yet small enough to meet functional requirements.

As a result, dimensions are variables. Relationships between these variables may be quite complex and difficult to express. Parts 1 and 2

IN DESIGN

A systematic study of methods for controlling effects of tolerances and design geometry

Part 1—Fundamentals: Precision and Accuracy

of this series introduce the principles on which the methods of formulating dimension relationships are based. Part 1 answers the question of how variability is defined; the meanings of precision and accuracy are discussed. Part 2 explains how dimensions are used to locate and describe points, lines, and surfaces in space; also, how dimensions are used to delineate the geometry of mechanical parts.

Precision and Accuracy: In everyday usage, the words *precision* and *accuracy* are synonymous, but when applied to the description of physical measurements they have different, although related, meanings. The exact nature of the relationship depends on how the words are defined. Regardless of definitions, however, the underlying significance of the words is the same. This significance can be illustrated with three targets, *Fig.* 1.

Accuracy is a measure of the closeness of the hits to the center of the target. *Precision* is a measure of the closeness of the hits to each other. Precision and accuracy are both relative measures and must be computed according to definite rules, however arbitrary, and compared with fixed standards.

Suppose that the rule for figuring the accuracy of the target hits is to give 20 points for each hit in the bullseye, 10 points for each hit in the middle ring, and 5 points for each hit in the outer ring. Thus for a set of 5 shots the standard of accuracy may be taken as 100, the greatest possible score. Accuracy then can be conveniently expressed as the ratio of the actual score to 100.

Following the same kind of reasoning, suppose that precision is measured as the diameter of the smallest circle that can be drawn around the hits. Furthermore assume that the standard of precision is the diameter of the bullseye. Precision can then be defined as the ratio of the diameter of the bullseye to the diameter of the circle drawn around the hits.

Obviously, from the target scores, a high degree of accuracy is possible only with a correspondingly

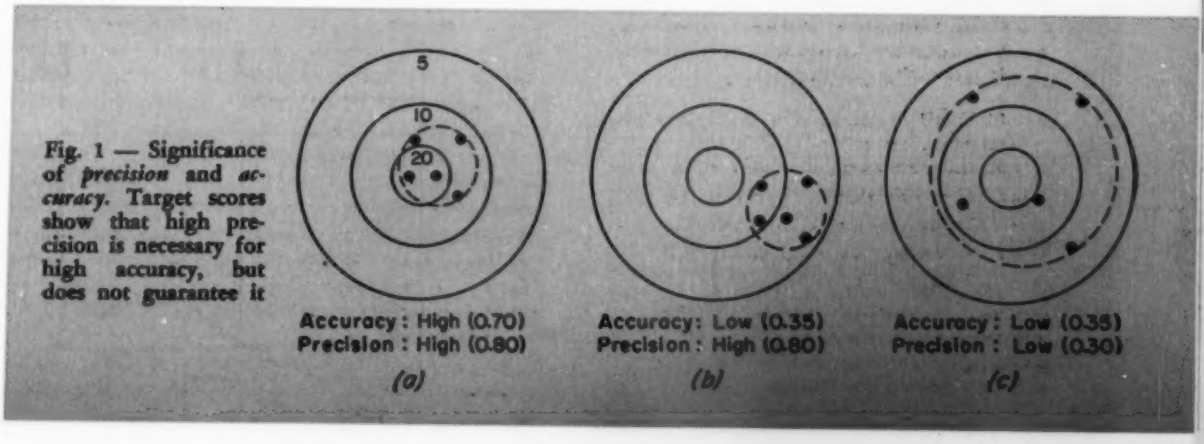


Fig. 1 — Significance of *precision* and *accuracy*. Target scores show that high precision is necessary for high accuracy, but does not guarantee it

high degree of precision. The converse is not necessarily true; a high degree of precision does not guarantee a high degree of accuracy. High precision and low accuracy may mean that an improvement in accuracy is possible.

Suppose, for instance, that the same marksman was responsible for the hits on targets *a* and *b* in *Fig.* 1. Location of the hits on target *b* might be blamed on badly adjusted sights which were corrected before firing on target *a*. Note that precision is the same for both targets *a* and *b* despite the wide difference in accuracy, and that accuracy is the same for targets *b* and *c* despite the wide difference in precision.

Whether these definitions of precision and accuracy for the targets are suitable depends on what they are used for. They may, for instance, give a good enough indication of skill at a shooting match, but be entirely inadequate for measuring the performance of a new military weapon. In the same way, suitability of a definition for the precision and accuracy of a dimension depends on what it is used for.

Thus, two separate methods of specifying a dimension have been found necessary to satisfy the various needs of dimension control. Each method is based on a different concept of a dimension; these concepts are illustrated in *Fig.* 2 for length dimensions. The definitions that follow, of course, are equally applicable to angle dimensions.

Simplest of the two concepts is that a dimension is represented merely by limits. The other, more sophisticated, concept is that the probable occurrence of any value of a dimension is known. Definitions of precision and accuracy are, quite naturally, different for each of these two concepts.

Limit Definition of Precision and Accuracy: The notation, x_a, shown in *Fig.* 2 is meant to express the idea that the dimension is a variable; a and A are the limits of this variable. Precision is a measure of the closeness of the various values of the dimension to each other. When no assumptions are made about the probable occurrence of intermediate values, precision is simply the difference between limits. The definition of precision in terms of limits is identical with the definition of tolerance:

$$t_a = |A - a|$$

Accuracy is a measure of the closeness of a value of x_a to the interval A, a. The definition of accuracy, corresponding to the definition of precision, is that a dimension value is accurate if it satisfies the condition $a \leq x_a \leq A$; if it does not satisfy the condition, then the value of the dimension is not accurate.

Definitions of precision and accuracy based on limits only are well suited for many dimension relationships. Moreover, the simplicity of these definitions make for comparatively easy calculations. For some situations, however, the study of dimension relationships founded wholly on limits does not yield very efficient results; tolerances called for may be unduly severe, or dimension conditions for which the limits are assigned may rarely occur in practice. When this is the case, methods of forming dimension relationships

Nomenclature

$A, B, \ldots$ = Upper (maximum) tolerance limits for dimensions $x_a, x_b, \ldots$
$a, b, \ldots$ = Lower (minimum) tolerances limits for dimensions $x_a, x_b, \ldots$
$f_P(x)$ = Probability function of dimension x
i = Individual number
n = Total number of individual values
P = Probability that a dimension will occur within its limits; a measure of accuracy
t = Tolerance, equal to the maximum tolerance limit minus the minimum tolerance limit
u = Standardized normal variable (standard deviation of a standardized normal distribution)
x = Dimension (a variable)
$\bar{x}$ = Mean (arithmetic average) dimension
ρ = Ratio, standard deviations of processing to measuring distributions
$= \sigma_p/\sigma_m$
σ = Standard deviation of a probability distribution
ξ = Mean (arithmetic average) of a theoretical, continuous probability distribution

Subscripts

$a, b, \ldots$ = Individual length dimensions or tolerances; defined by A, a; B, b; . . . for limit dimensions
i = Individual value
m = Of a measurement distribution
p = Of a process distribution

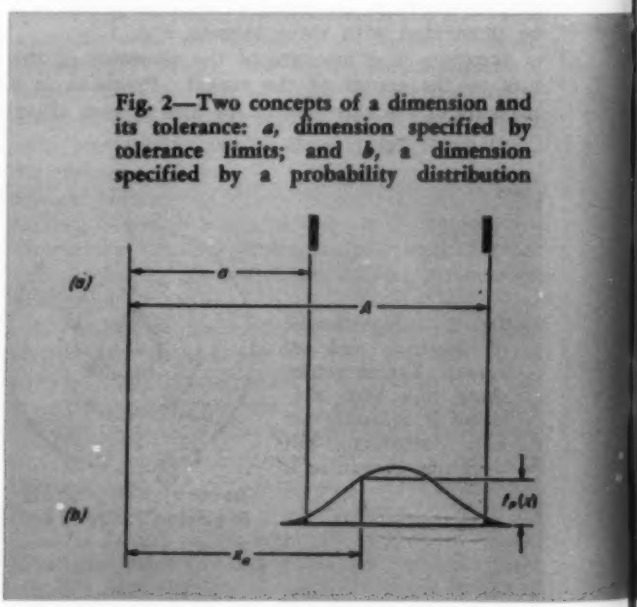


Fig. 2—Two concepts of a dimension and its tolerance: *a*, dimension specified by tolerance limits; and *b*, a dimension specified by a probability distribution

based on probability distributions may prove to be much more effective.

Probability Definition of Precision and Accuracy: Formulating dimension relationships in terms of probability distributions is a particular application of probability theory. One of the attractions of probability theory is that definitions of precision and accuracy can be made in terms fundamental to the theory. To apply probability methods, the designer should have an understanding of those parts of the theory associated with dimension control.[1]

An efficient measure of how close the various values of a dimension distribution tend to cluster about the mean value is the *standard deviation*, σ. The significance of the standard deviation is more readily exhibited for a sample than for a theoretical distribution of values. Suppose that the dimensions x of n similar parts have been gaged and the values tabulated in *Fig.* 3. The standard deviation is calculated as the positive value of

$$\sigma = \left[\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2 \right]^{1/2}$$

where the mean value

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

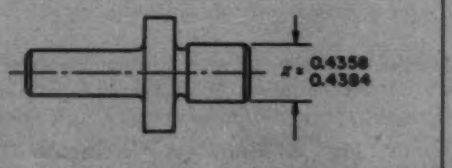
For the sample distribution the standard deviation is 0.00058-in. This figure may also be used as a measure of the precision of the sample distribution.

Accuracy of a sample distribution can be calculated as the percentage of dimension values that fall between the limits. Thus, accuracy of the sample is (33/36)(100) = 91.6 per cent. If the sample is a reliable indication of future production, approximately 91.6 per cent of the parts made will be within limits, and 8.4 per cent will not.

Definitions of precision and accuracy for samples, although valuable for investigating the performance of a machine or process, are not especially helpful to the designer. Useful definitions must be in terms of *limits*—for the final results of a dimension study are dimensions for manufacturing drawings. The probability distribution and the standard deviation are, however, the basis for defining precision and accuracy for probability re-

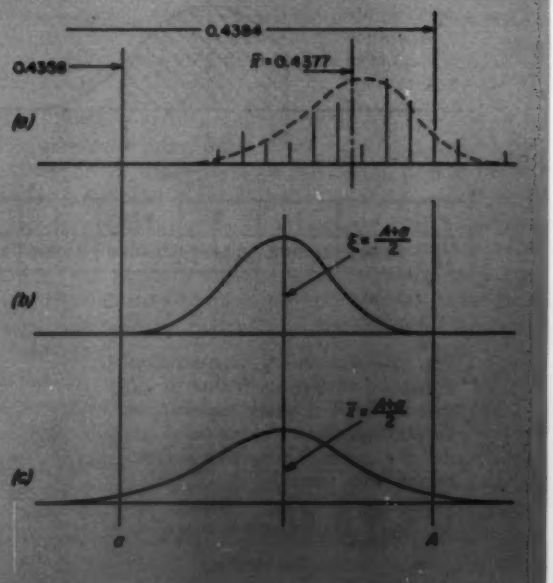
1. A. Hald—*Statistical Theory with Engineering Applications*, John Wiley & Sons Inc., New York, 1952. (Extensive book without advanced mathematics. Following chapters are particularly significant to engineering designers: Chapter 4—Definitions and Fundamental Properties of Empirical Distributions; Chapter 5—Definitions and Fundamental Properties of Theoretical Distributions; Chapter 6—The Normal Distribution; Chapter 13—Statistical Control.)

Fig. 3 — Sample dimensions from 36 parts. Note that three parts—13, 15 and 26 — are out of tolerance



i	x_i	i	x_i	i	x_i
1	0.4374	13	0.4389*	25	0.4368
2	0.4380	14	0.4365	26	0.4385*
3	0.4380	15	0.4385*	27	0.4370
4	0.4373	16	0.4375	28	0.4380
5	0.4371	17	0.4382	29	0.4376
6	0.4376	18	0.4376	30	0.4376
7	0.4384	19	0.4367	31	0.4383
8	0.4379	20	0.4382	32	0.4375
9	0.4378	21	0.4370	33	0.4372
10	0.4374	22	0.4379	34	0.4382
11	0.4377	23	0.4368	35	0.4373
12	0.4381	24	0.4379	36	0.4382

Fig. 4—Three different dimension distributions. The sample dimensions from *Fig.* 3 are ploted at *a* with a "fitted" normal curve and calculated mean. An ideal normal distribution, *b*, has essentially all dimensions falling within the tolerance zone. A practical controlled distribution, *c*, has a specified percentage of dimensions falling within the tolerance zone



lationships. A useful definition of precision and accuracy based on probability distributions and standard deviations will now be developed.

Accuracy and Precision in Practice: The notation $f_P(x)$ is used to represent a probability function. In *Fig.* 2 the probability function $x_a = f_P(x_a)$ is shown graphically. The function can be discontinuous as in a sample distribution or certain theoretical distributions like the binomial, or continuous as in the distribution shown in *Fig.* 2.

For a continuous, theoretical distribution, the standard deviation

$$\sigma = \left[\int_{-\infty}^{\infty} (x - \xi)^2 f_P(x)\, dx\right]^{1/2}$$

where ξ is the mean of the theoretical distribution and corresponds to the sample mean $\overline{x}$. When the parameters of a probability function $f_P(x)$ are chosen so that the area between the X axis and the curve is unity, accuracy is expressed by the integral:

$$\int_a^A f_P(x_a)\, dx$$

This expression for accuracy is valid only if: (1) the form of the theoretical distribution $f_P(x_a)$ and the distribution that actually occurs in practice are alike; and (2) if the mean of the theoretical distribution coincides with the mean of the actual distribution.

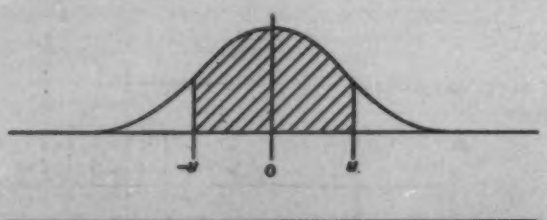
This coincidence is not likely to happen. For example, it did not happen for the sample dimensions of *Fig.* 3. *Fig.* 4*a* shows the distribution of the sample; and *Fig.* 4*b* shows an ideal normal distribution with $\xi = \overline{x}$.

Two distinct sources of variation in the distribution of the sample dimensions may be identified. One of these, due to process variation, is represented by the form of the distribution and the standard deviation; the other, due to measurement variation, is represented by the position of the sample mean.

Process variation is a characteristic of a particular machine or process. Measurement variation is a term that is used to include the combined effect of inaccuracies of measurement, temperature variations, operator bias, and so forth. The question is, how are the two sources of variation, process and measurement, included in a useful definition of accuracy?

This question may be answered once it is recognized that measurement variation is not a fixed value but, like process variation, also has a probability distribution. By combining the process distribution and the measuring distribution, a practical distribution may be formed; *Fig.* 4*c* represents such a distribution. If the standard deviation of the measurement variation is large, the theoretical accuracy of the practical distribution will of course be much less than the accuracy of a corresponding ideal distribution.

Accuracy depends on the size of the tolerance and on the standard deviations and forms of the process and measuring distributions. Any number of distributions are found in practice. But the normal distribution is a reliable approximation of many of the dimension distributions found in practice. Therefore, a useful definition of precision



u	1	2	3	3.75	4	∞
Area $= P$	0.6826	0.9545	0.9973	0.9998	0.9999	1.0000

Fig. 5—Above—A standardized normal distribution. Value of the standardized normal variable, *u*, determines the area bounded under the curve. Thus, it also determines the probability, *P*, of a dimension falling within the limits of plus and minus *u*

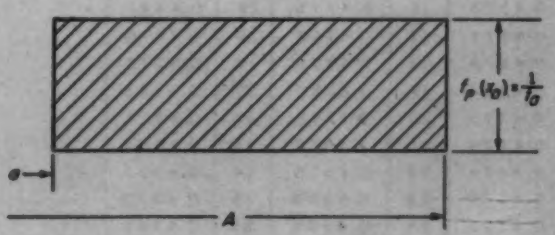


Fig. 6—Below—A rectangular distribution. Every dimension is presumed to fall between *A* and *a*, so accuracy is 100 per cent

and accuracy can make use of the normal distribution. For situations where normality may not be a reliable assumption, the rectangular distribution is used instead.

Using the Normal Distribution: Because of the unique properties of the normal distribution, a linear combination of two or more independent normal distributions is also normally distributed. Moreover, the standard deviation of the new distribution is a simple combination of the standard deviations of the principle distributions. Thus, if σ_p is the standard deviation of a process distribution and σ_m the standard deviation of a measuring distribution, the standard deviation of the practical distribution is

$$\sigma = \sqrt{\sigma_p^2 + \sigma_m^2} \quad \ldots\ldots (1)$$

which is of course a measure of precision for the practical distribution.

A relationship connecting tolerance and standard deviation for a normal distribution is

$$t = 2u\sigma \quad \ldots\ldots (2)$$

where u is called the *standardized normal variable*. The area under a standard normal curve bounded by $\pm u$ is a measure of accuracy. The significance of u is illustrated by *Fig.* 5.

Repeating the main points, Equation 2 is a statement that relates tolerance to measures of precision (σ), and accuracy (u). However, a more useful expression can be obtained by combining Equations 1 and 2, and letting

$$\rho = \frac{\sigma_p}{\sigma_m}$$

The result is the equation

$$t = \left(\frac{\sqrt{\rho^2 + 1}}{\rho} \, 2u \right) \sigma_p \quad \ldots\ldots (3)$$

Table 1 gives values of the function relating t and σ_p.

For an example of how Equation 3 is applied, assume that the standard deviation of the dimensions in *Fig.* 3 is representative of the manufacturing process so that $\sigma_p = 0.00058$-in. If $\sigma_p/\sigma_m = 3$ is assumed, and if u is taken as 3.79, corresponding to an accuracy of 99.98 per cent (*Fig.* 5) then, referring to *Table* 1,

$$t = 8\sigma_p = 0.0046\text{-in.}$$

Compare this with the sample dimension tolerance of 0.0026-in.; the sample tolerance is not very practical if a high degree of accuracy is wanted.

The usefulness of Equation 3 is limited to normal distributions. It is only as reliable as the estimate of process and measuring variability. More conservative measures of precision and accuracy are in order when normality cannot be assumed nor estimates of variability made with confidence. The most conservative definition of precision and accuracy is by limits; other conservative definitions can be made for rectangular distributions.

Using Rectangular Distributions: The rectangular distribution is shown in *Fig.* 6. For a given tolerance, the standard deviation of a rectangular distribution is $t/3.46$ as compared, say, with $t/8$ for a normal distribution. In other words, precision is about 2.3 times greater for the normal than for the rectangular distribution. Accuracy again is the area under the curve bounded by the limits; in this case the curve is a straight line. For practical purposes the accuracy of a rectangular distribution is always set at 100 per cent; all dimensions are presumed to fall within the tolerance range. Additionally, any dimension within the range is presumed to occur with equal probability.

Significance of the Definitions: The practical meaning of precision and accuracy are fully demonstrated when the effects of combinations of dimensions in mechanisms and structures are considered in later articles of this series. Combinations of dimensions, however, are based on how dimensions are used to describe and locate points, lines, and surfaces in space. These questions are discussed in the next article, Part 2 of this series.

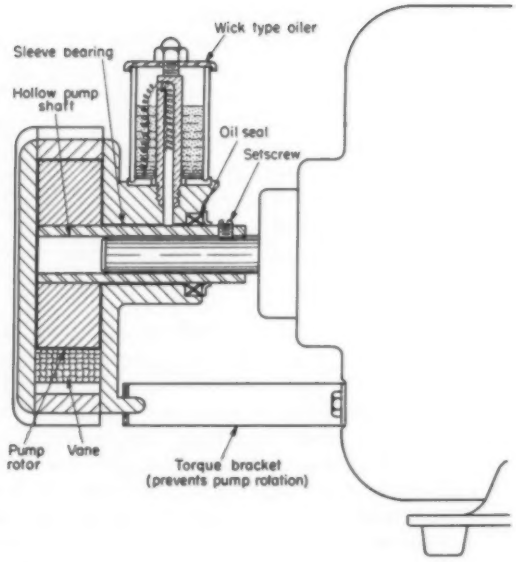
Table 1—Values of Function for Equation 3:

$$\frac{\sqrt{\rho^2 + 1}}{\rho} 2u$$

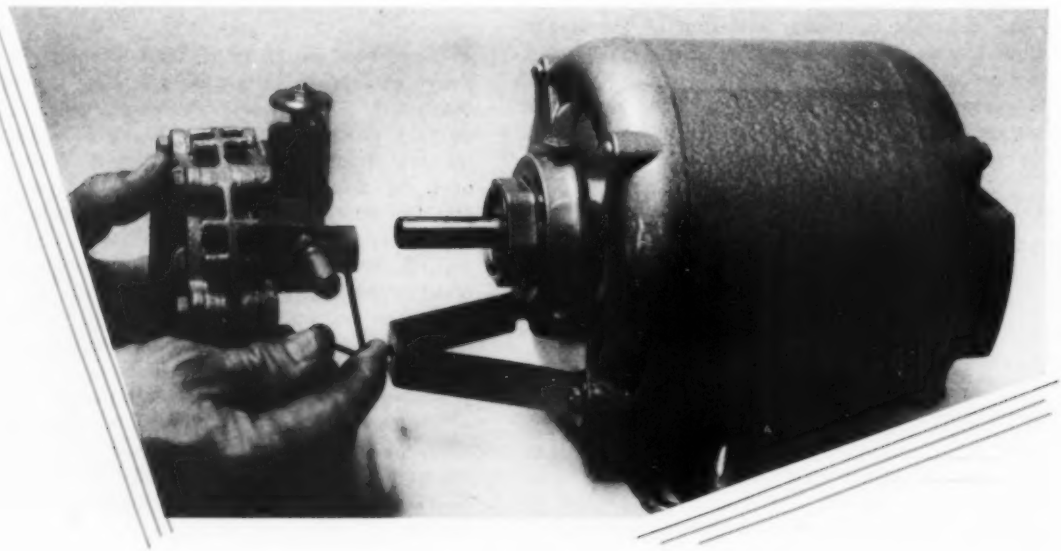
ρ	$u = 2$	$u = 3$	$u = 3.79$	$u = 4$
2	4.48	6.72	8.46	8.96
3	4.20	6.30	8.00	8.40
4	4.12	6.18	7.79	8.24

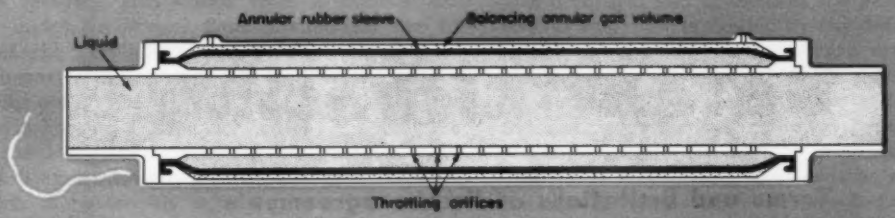
"Science is not a lot of book-learning; it is an active enterprise. It is what scientists do and how they do it. They do not wave magic wands, neither do they proceed by a series of rigid logical steps to sure conclusions. Instead, they keep their eyes open for discrepancies between actual phenomena and the current explanations for them, and they try to improve them in order better to understand, control, and predict. They devise instruments for observation and measurement. They use imagination to set up hypotheses, which they test by carefully designed and controlled experiments. Results found to occur so uniformly as to have high probability of recurrence are formulated as "laws," although it is understood that, unlike statute laws, they do not control. These laws are explained, where possible, by theories and models." — JOEL H. HILDEBRAND, *president, American Chemical Society*

scanning the field for Ideas



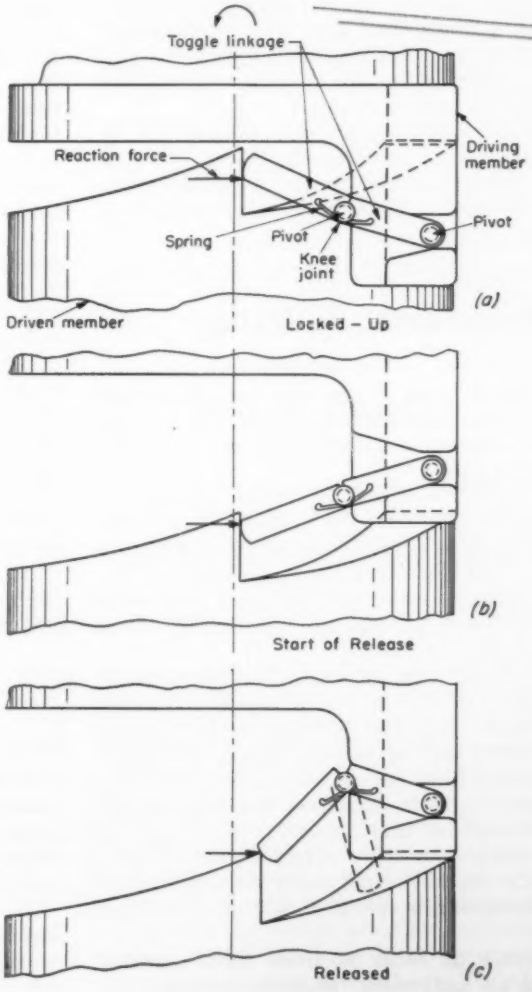
CANTILEVER MOUNTING of mechanically rotated assemblies on motors minimizes alignment problems. Employed in the design of a new line of vane type vacuum pumps developed by Perfection Mfg. Co., this mounting technique eliminates need for separate shaft couplings required for base-mounted units, or motors with special end bells for motor-mounted types of assemblies. Mounting is accomplished by means of a hollow pump drive shaft machined for a slip-fit on standard-diameter motor shaft extensions.





AUTOMATIC DAMPING of excessive pulsations and pressure surges in liquid-carrying lines is achieved with through-flow pulsation damper design. The Desurger, which was developed by the Westinghouse Air Brake Co., operates by accumulating and discharging excessive pressure through a metal tube which contains numerous specially designed throttling orifices. Around this tube is a rubber sleeve which, by means of air contained in a surrounding pressure chamber, is held close to the throttling orifices under steady liquid-flow conditions. During surge periods, the excess pressures are dissipated by forcing liquid through the orifices and distending the sleeve against the precharge of air in the outer chamber.

POSITIVE DISENGAGEMENT of a self-releasing jaw clutch is assured by a toggle-linkage lock-up and release. Utilized in the design of a self-releasing tap holder developed by Joseph Kalafsky of Cleveland, the toggle linkage is fastened on a pivot to the driving member and is constructed with a knee joint in the center. Lock-up occurs as long as the toggle-linkage is positioned between driving and driven members as shown in *a*. In this position the reaction force developed by the driven member against the free end of the linkage passes through the noncollapsing side of knee-joint pivot center. As the driven member of the clutch moves axially away from the driving member as in *b*, the reaction passes through the other side of the knee pivot center; under these conditions, the toggle linkage immediately collapses as in *c*, releasing the driving power.



Patent Licensing

Terms and limitations of license agreements as defined by statutes and court decisions

By Albert Woodruff Gray
Forest Hills
New York

A SIGNIFICANT provision of the patent statute is: "Subject to the provisions of this title, patents shall have the attributes of personal property. Applications for patents, patents, or any interest therein shall be assignable in law by an instrument in writing."

On this provision rests not only the right of an inventor to sell or transfer his patent, but the collateral right to license its use to others while retaining ownership of the patent and its attendant monopoly.

Fundamental Distinction

In the latter years of the last century, a case came before the Supreme Court which involved the distinction between a patent assignment and the licensing of a patent.

"Every patent," said that court, "issued under the laws of the United States for an invention or a discovery contains 'a grant to the patentee, his heirs and assigns, for the term of seventeen years, of the exclusive right to make, use and vend the invention or discovery throughout the United States and the territories thereof.'

"The monopoly thus granted is one entire thing and cannot be divided into parts except as authorized by those laws. The patentee or his assigns may by instrument in writing assign, grant and convey either, first, the whole patent comprising the exclusive right to make, use and vend the invention throughout the United States; or second, an undivided part or share of that exclusive right; or third, the exclusive right under the patent within and throughout a specified part of the United States.

"A transfer of either of these three kinds of interest is an assignment, properly speaking, and vests in the assignee a title in so much of the patent itself, with the right to sue infringers; in the second case, jointly with the assignor; in the first and third cases, in the name of the assignee alone. Any assignment or transfer short of one of these is a mere license, giving the licensee no title to the patent and no right to sue at law in his own name for an infringement."

Then of a license or the transfer of a limited right in a patent the court added, "When the transfer amounts to a license only, the title remains in the owner of the patent and suit must be brought in his name and never in the name of the licensee alone unless that be necessary to prevent an absolute failure of justice as where the patentee is the infringer and cannot sue himself.

"The grant of an exclusive right under the patent within a certain district which does not include the right to use and the right to sell is not the grant of a title in the whole patent right within the district and is therefore only a license. Such for instance, is a grant of 'the full and exclusive right to make and vend' within a certain district, reserving to the grantor the right to make within the district to be sold outside of it. So is a grant 'of the exclusive right to make and use' but not to sell patented machines within a certain district."

License Restrictions

A license had been granted by the owners of patents of vacuum-tube amplifiers to but two companies for commercial use, while for private or home use licenses had been granted to 50 or more manufacturers. On the tube carton was the notice, "The sale of this device carries a license under the patent claims only for talking machine use, radio experimental uses and broadcast reception and only where no business features are involved."

In sustaining a judgment for infringement

against a commercial user who had purchased amplifiers carrying this notice from a licensee excluded under its license from commercial use or sales of the amplifiers, the Supreme Court said of such restrictive licenses, "The question of law requiring decision is whether the restriction in the license is to be given effect. That a restrictive license is legal seems clear. The patentee may grant a license upon any condition the performance of which is reasonably within the reward which the patentee by the grant of the patent is entitled to secure. The restriction here imposed is of that character. The practice of granting licenses for a restricted use is an old one. As the restriction was legal and the amplifiers were made and sold outside the scope of the license the effect is precisely the same as if no license whatever had been granted to the manufacturer. And as the purchaser from the manufacturer knew the facts it is in no better position than if it had manufactured the amplifiers itself without a license."

Provisions in a patent licensing agreement granting a nonexclusive right to the manufacture of diesel engines restricted the licensee to the manufacture of stationary, marine, industrial and automobile engines with a piston displacement of more than 1000 cubic inches and excepted from these restrictions airplane and passenger car engines.

Later, when a suit was brought to recover unpaid royalties, the defense was an attack on the validity of these restrictions, charging that they violated the antimonopoly statutes.

"The owner of the patent need not allow anyone to use it for any purpose," said the Delaware court in sustaining this license agreement. "Clearly, if he does permit someone to use it he may impose any lawful restrictions upon the privilege. Moreover he may limit its use to one or more of the several fields of its use. He is not forced to permit an all inclusive use."

By adopting this principle of patent licensing in the marketing of rotary drill bits, a western tool manufacturer protected its drills from the ill effects of incompetent maintenance in the retipping of worn-out drills. These drills were not sold but leased by the tool manufacturer and each lot was tagged, "Hughes roller rack bits and all core bit heads are never sold but leased. When the original cutter teeth and/or bearings have served their useful life the user will surrender the bits to the Hughes Tool Company upon request. In accepting delivery the user agrees not to surrender any of the tools mentioned above to other than the duly authorized representative of the Hughes Tool Company."

In a recent action before a Federal appellate court, the tool company contended that its patents had been infringed by oil well equipment repairers in the reconstruction and retipping of these drills. The defense was that by these licenses or license agreements the tool company was maintaining a monopoly for its products.

Of time as a factor in the restriction of patent licenses, the court said here, "The patent law confers on the patentee a limited monopoly. It operates to create a grant to the patentee, an exclusive right to make, use and vend the particular device described and claimed in the patent. The extent of the right is limited by the definition of the invention, and its boundaries are marked by the specifications and claims of the patents.

"Had the lease agreements, instead of providing for their termination when the useful life of the original cutter teeth and/or bearings ended, provided that they should terminate on specific dates the use or repair of a bit leased under such an agreement after the expiration of the date stated therein would have constituted infringement.

"The lease agreements provided that the right of the lessee to use the bits should terminate upon the occurrence of a future event, namely, the end of the useful life of the original teeth, an event which would occur in normal course as the result of the use of the bits. That provision imposed nothing more than a restriction as to time. When such event occurred the right of the lessee to use the bit ceased and with it his right to repair the bit and the repair of the bit thereafter constituted an infringement."

Then, in outlining the limits on the use of patent licensing agreements, the court added, "The patentee in granting a license may not require a licensee to purchase patented goods for use with the patented apparatus, prohibit the use by the licensee of goods of a competitor, condition the granting of the license upon the acceptance of another and different license, control the resale prices of the patented articles after he has sold them, use his patent to protect an unpatented element for competition or otherwise enlarge the monopoly granted by the patent. But here, as we have indicated, Hughes by the lease agreements merely imposes a limitation as to the time the bits may be used, a limitation clearly within the range of its patent monopoly."

Limit of Control

Even the reference in the previous decision to the prohibited use of patent license agreements for the control of retail prices after the patentee has sold the goods is not a prohibition against the setting of prices by the agents of the licensor. This was clearly pointed out by the United States Supreme Court in its decision of a suit by the government against an electrical products manufacturer on the charge of a violation of the antitrust laws by the establishment of the prices to be maintained by licensed agents of the manufacturer.

There the Supreme Court said of the limits to the control of the prices at which patented goods may be marketed by the licensee, "It is well settled, as already said, that where a patentee makes a patented article and sells it, he can exercise no future control over what the purchaser may wish to do with the article after his purchase. It has passed beyond the scope of the patentee's rights.

"But the question is a different one which arises when we consider what a patentee who grants a

license to one to make and vend the patented article may do in limiting the licensee in the exercise of the right to sell.

"The patentee may make and grant a license to another to make and use the patented article but withhold his right to sell it. The licensee in such a case acquires an interest in the articles made. He owns the material of them and may use them. But if he sells them he infringes the right of the patentee and may be held in damages and enjoined.

"If the patentee goes further and licenses the selling of the articles, may he limit the selling by limiting the method of sale and the price? We think he may do so provided the conditions of sale are normally and reasonably adapted to secure pecuniary reward for the patentee's monopoly."

Legal Authority

In guarding against licensing abuses, the law holds that the right to set the selling price ceases when the ownership passes from the patent owner to the purchaser.

"While it is true," asserted the Supreme Court in a decision that has become an authoritative statement of the law on this particular, "that under the statutes as they were and now are, a patentee might withhold his patented machine from public use, yet if he consented to use it himself or through others, such use immediately fell within the terms of the statute and he is thereby restricted to the use of the invention as it is described in the claims of his patent and not as it may be expanded by limitations as to materials and supplies necessary to the operation of it imposed by mere notice to the public.

"The owner of a patent is not authorized by either the letter or the purpose of the law to fix by notice the price at which the patented article must be sold after the first sale of it. The right to vend it is exhausted by a single unconditional sale, the article sold being thereby carried outside the monopoly of the patent law and renders free of every restriction which the vendor may attempt to put upon it."

To this the court added, in conclusion, "A restriction which would give to the patentee such a potential power for evil over an industry is plainly void because wholly without the scope and purpose of our patent laws and because if sustained it would be gravely injurious to that public interest which we have seen is more a favorite of the law than is the promotion of private fortunes."

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2. Williams v. Hughes Tool Co., 186 *Fed.* 2d 278, December 2, 1950.
3. United States v. General Electric Co., 272 *U. S.* 476, November 23, 1936.
4. Motion Picture Patents Co. v. Universal Film Mfg. Co., 243 *U. S.* 502, April 9, 1917.
5. 35 *U.S.C.A.*, sec. 261.
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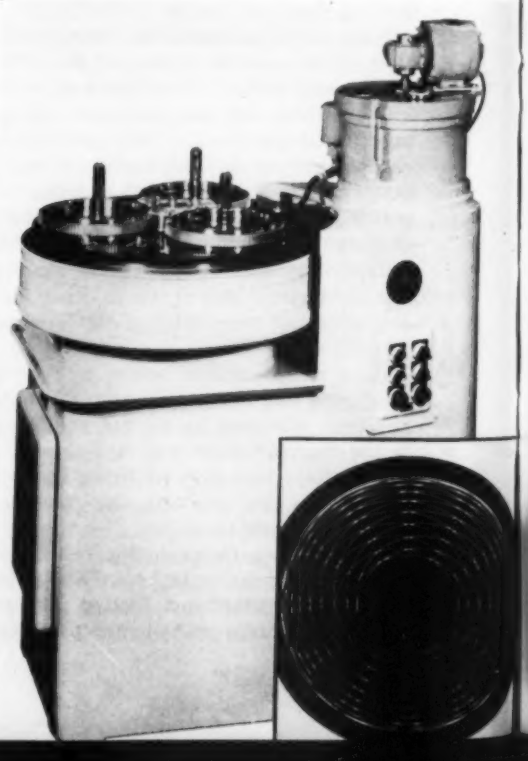
Contemporary Design

Lapping Machine Simulates Hand Motion

ECCENTRIC motion of the center drive gear of a new lapping machine is said to simulate the figure 8 motion used in hand lapping. This unique motion combined with precision lapping plate supports will produce lapped surfaces that are optically flat to one light band or 0.0000116-inch in a fraction of the time required by hand methods. The machine is a product of Spitfire Tool Co. and has been labelled the Gyro-Matic 21.



When—and when not—to use the master-gear method for specifying size of

Precision Gears

By Richard L. Thoen

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Mechanical Div.
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IN THE field of precision gearing the so-called size of a spur gear has been the subject of much discussion. Most discussions are concerned with ways in which gear size is nearly always measured: (1) as a dimension over pins or (2) in terms of center distance determined by rolling the gear in tight mesh with a master gear. The first method is quite popular since pin checks are simple and easy to make, whereas center-distance checks are more involved and are subject to the various inaccuracies that may be present in the center-distance gaging unit.

However, size measurements obtained with pins are not as reliable as measurements obtained with an accurate center-distance gage. The center-distance method is much more realistic than the pin method of checking. Rarely is there agreement between the two methods. Pins are useful, but it is necessary to understand their limitations before they can be effectively applied.

In recent years it has become evident that there are also inherent limitations in the master gear method. For example, apparent differences exist between the center distance at which two mating gears *should* mesh tightly, as indicated by a master, and the center distance at which they *do* mesh tightly. These discrepancies in measurement have raised questions about the manner in which gear size is specified and measured. In particular,

1. Does a basic error in measurement come into play when a perfect master is used to determine the size of an imperfect gear?
2. If so, does the magnitude of the error depend upon the number of teeth in the master?
3. How should the accuracy of the master gear

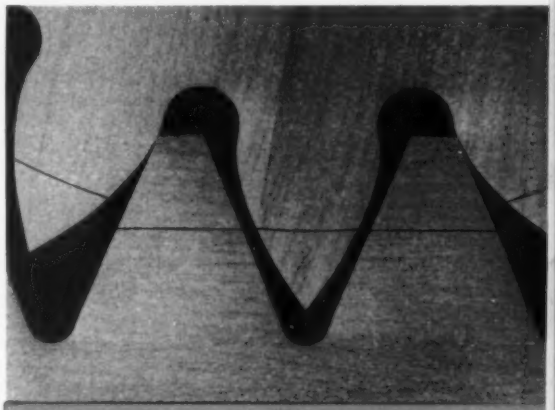


Fig. 1 — An imperfect pinion meshing with a master rack

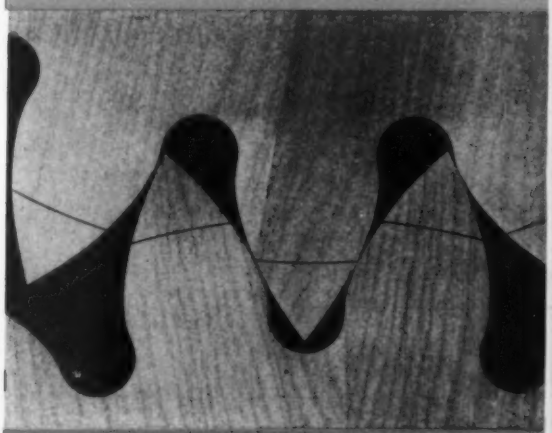


Fig. 2 — Imperfect pinions that have been sized with a master rack

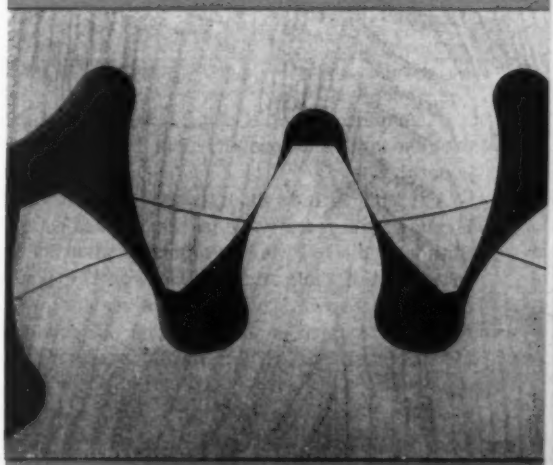


Fig. 3—An imperfect pinion meshing with a master gear

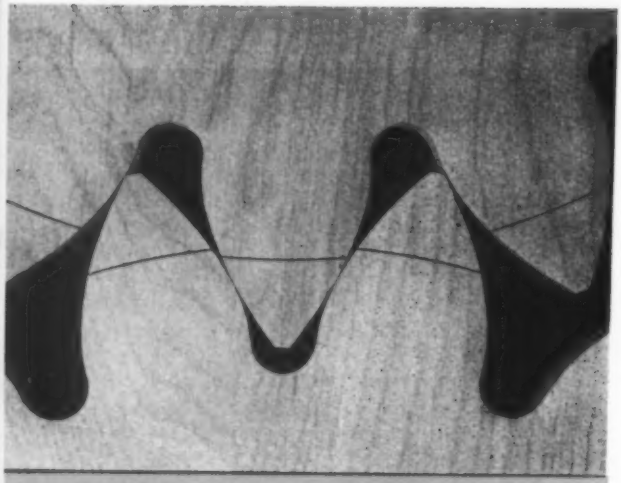


Fig. 4 — Imperfect pinions that have been sized with a master gear

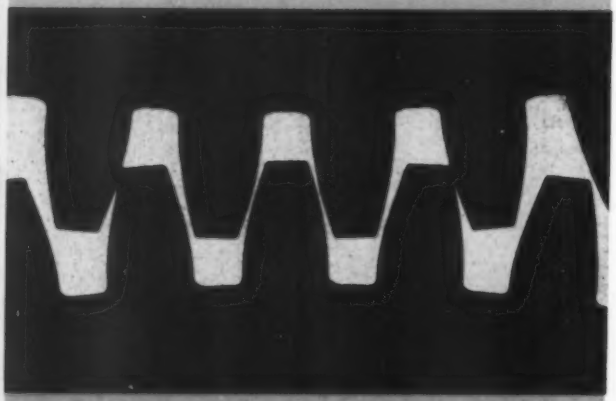


Fig. 5—A mesh in which two teeth fail to make contact

compare with the accuracy required of the gear under test?

A graphic example, *Fig.* 1, helps to define the problem and answers the first two questions in a general way.

A pinion with an exaggerated error in base pitch is shown in mesh with a master rack in *Fig.* 1. Standard pitch lines have been drawn on the side faces of the rack and pinion. For the position of the gears shown, the pinion is meshing with the rack at standard center distance. If this combination of rack and pinion were mounted on a variable-center-distance fixture, the observed center distance would vary within certain limits as the pinion rotated. Maximum center distance would occur with a pinion tooth in the center of the mesh, and the minimum center distance with a rack tooth in the center. This is typical of the condition that exists when a gear is cut so as to mesh at a given center distance with a master gear or rack. That is, the operator must adjust the gear-cutting machine so that the maximum center distance (rather than an average or the minimum) between the gear and the master will meet a given dimension.

If other gears were cut to mesh at standard center distance with the same master rack, it would seem that, as in *Fig.* 1, any two of the gears would mesh tightly at standard center distance. However, this is not the case as shown in *Fig.* 2 where two pinions of the type shown in *Fig.* 1 are meshed together. Instead of being tangent to each other, the standard pitch circles intersect and, if the pinions were meshed at standard center distance, backlash would result.

Both pinions shown in *Fig.* 2 have an identical error in base pitch and thus would roll together without any variation in center distance. If these pinions had been cut to mesh at standard center distance with a standard master gear, *Fig.* 3, instead of with the master rack, they would mesh as shown in *Fig.* 4.

Comparison of the intersections of the standard pitch circles in *Figs.* 2 and 4, shows that the center-distance error with a master rack is greater than the error with a master gear. Also, in both cases the tooth thickness is less than standard, which is apparent when one compares the width of the top land on the pinions in *Figs.* 2 and 4 to the width of the top land on the standard master gear, *Fig.* 3. Such a result might be suspected. For two gears—one defective and one perfect—to mesh at the same center distance with a master gear, the teeth of the defective gear would necessarily be thinner than the teeth of the perfect gear.

Thus, questions 1 and 2 are answered in a general way. A basic error in measurement does arise when a perfect master is used to gage the size of an imperfect gear. And, magnitude of that error is dependent upon the number of teeth in the master.

To analyze the gaging errors caused by all types of gear defects would be extremely difficult. In addition, the effort would scarcely be worthwhile since the end result of such an analysis would be a complicated working formula which would express the total gaging error as a function of the gear defects. To determine the gaging error, one would have to know the magnitude and phase of all of the existing gear defects. If these were known, there would be little need for using a master.

However, a limited analysis can be beneficial if the end result yields information which points out some condition of practical importance. For instance, a limited investigation might disclose that the gaging error is particularly sensitive to certain commonplace gear defects. Then, such information would be of value whenever a decision had to be made as to the manner in which the size of a gear was to be specified and measured. The designer would know, at least approximately, the point at which it would no longer be meaningful

to specify gear size in terms of a rolling center distance with a master.

To aid in such an analysis, the gaging errors that arise from errors in pressure angle and circular pitch are presented here.

Uniform errors in pressure angle and circular pitch can be resolved into an error in base pitch:

$$\Delta p_b = (\Delta p) \cos \phi - p\,(\Delta\phi) \sin \phi$$

where Δp_b = error in base pitch, inches; θ = pressure angle, degrees; Δp = error in circular pitch, inches; p = circular pitch, inches, and $\Delta\theta$ = error in pressure angle, radians.

Errors in base pitch are very common and in most cases are readily measured. Also, the same cutting tool will tend to produce similar errors in base pitch in successive gears. It can therefore be assumed that the following conditions exist:

1. Both mating gears mesh tightly at standard center distance with a master gear or master rack of standard proportions.
2. The outside diameters of both mating gears are standard and, except for an identical error in base pitch, are perfect in every respect.
3. The magnitude of the error in base pitch is sufficiently small that, at maximum center distance with the master, the number of profiles in contact will not differ from the number that would contact if there were no error in base pitch, and that tooth contact does not occur at the intersection of the top land and the tooth surface.

When two gears are meshed tightly with each other under these conditions, the center distance will be less than standard. The amount of reduction depends upon the pressure angle and the number of teeth in the masters and in the gears. Values for various conditions are listed in *Table* 1.

As an example, consider two 14½-degree pressure angle gears which have 279 teeth or less. Assume one gear has been sized with a master of 280 teeth or more (which includes rack masters), and the other gear has been sized with a master of 279 teeth or less. Then, for a negative error in base pitch, the center distance reduction is 8.0 times the error in base pitch. If the base pitch error were 50 microinches, the gears would mesh with each other at a center distance 0.0004-inch less than standard.

The numbers 16, 17, 279 and 280 appear in *Table* 1 because a change in the nature of the tooth contact can occur at these points. In passing from 16 to 17 teeth, the tooth contact can change from that shown in *Fig.* 3 to that shown in *Fig.* 1. That is, a straddling effect takes place. In passing from 279 to 280 teeth, the tooth contact can change from that shown in *Fig.* 1 to that shown in Fig. 5. Two gear teeth fail to make contact with the master. In practice these transitions do not occur exactly at 17 and 280 teeth since the number of teeth in contact

Fig. 6 — Increase in center distance that results from a unit error in base pitch

Curve	Pressure Angle (deg)	Number of Gear Teeth	Base Pitch Error
A	14½	280 or more	minus
B	14½	279 or less	minus
C	14½	Any	plus
D	20	17 or more	minus
E	20	17 or more	plus

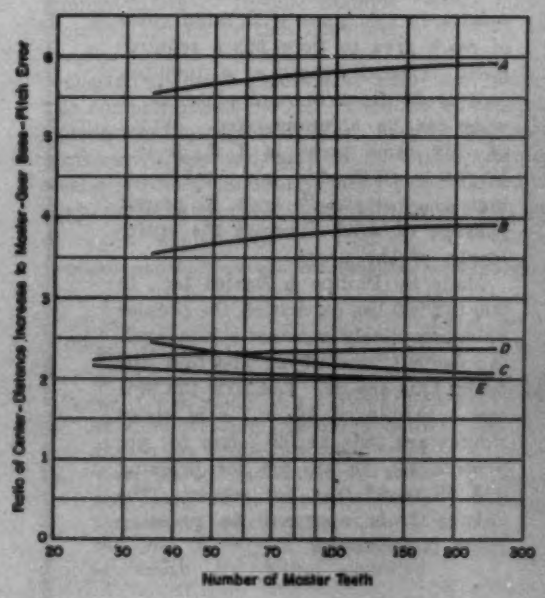


Table 1—Center-Distance Reduction for Unit Base-Pitch Error

Pressure Angle (deg)	No. of Teeth in Gear Pair	No. of Teeth in Master Gear	Center Distance Reduction Base Pitch Error +	Base Pitch Error −
20	16 or less	17 or more	1.5	1.5
	16 or less	17 or more		
20	17 or more	17 or more	4.4	4.4
	17 or more	17 or more		
20	16 or less	17 or more	2.9	4.4
	17 or more	17 or more		
14½	279 or less	279 or less	6.0	6.0
	279 or less	279 or less		
14½	279 or less	280 or more	6.0	10.0
	279 or less	280 or more		
14½	280 or more	279 or less	10.0	6.0
	280 or more	279 or less		
14½	279 or less	279 or less	6.0	8.0
	279 or less	280 or more		
14½	279 or less	279 or less	8.0	6.0
	280 or more	279 or less		
14½	279 or less	280 or more	8.0	8.0
	280 or more	279 or less		

is not the same as when there is no error in base pitch. In addition, variations in tooth thickness and outside diameter alter the points at which these transitions occur. Also, undercut of the involute, which depends upon the geometry of the cutting tool, can affect the nature of the tooth contact on small pinions.

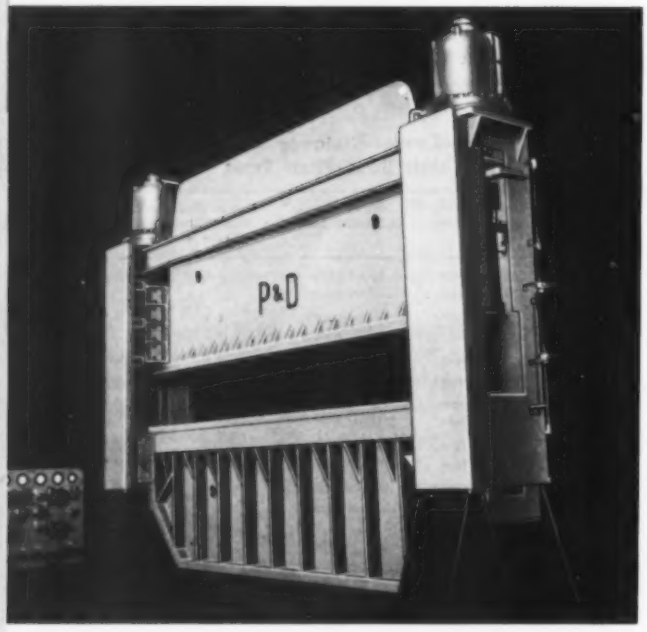
How accurate a master gear must be in comparison to the accuracy required of the gear to be tested can be demonstrated by an example. Assume that a master gear of standard outside diameter is manufactured to meet the standard dimension over $1.728/P$ pins (where P is the diametral pitch) and, except for a uniform error in base pitch, is perfect in every respect. Then, if the master were meshed with a perfect gear of standard proportions, the center distance would be larger than standard by an amount shown in *Fig.* 6. For example, if a 100-tooth, 14½-degree master gear with a negative error of 25 microinches in base pitch were meshed with a gear of less than 279 teeth, the center distance would be 25×3.8 or 95 microinches greater than standard, an apparent error of 0.00019-inch in the diameter of the gear under test.

Master gears and master racks play an important part in the determination of gear size and will continue to do so in all except the most precise measurements. Since the term "precise" is relative, the numerical values given in *Table* 1 and *Fig.* 6 serve to locate the general regions in which discrepancies in measurement can occur.

However, only one of the many types of gear defects has been discussed here. In practice the magnitude of the observed gaging errors may deviate from the theoretical values. Also, since the nature of the gear defects common in one plant may differ from those in another, the magnitude of the gaging errors may also differ from one to another. Thus, production experience is essential to a full understanding of gear gaging errors and to their consideration in design specifications.

Contemporary Design

Press Design Is Wide Open



CLEAN, open design of a newly introduced line of press brakes results in machines with high ratio of work area to floor space requirement. Overall length of a 1000-ton unit is 26 ft, 1 in. and plate 19 ft wide can be accommodated. Width of this same press is 4 ft, 6 in.; height is 16 ft, 5½ in. End housings are completely open to permit passage of work through the entire length of the press.

Made by Philips & Davies Inc., in 500 to 2000 ton capacities, the presses have completely automatic ram-leveling devices, ram tilting and four different ram speeds. The 1000-ton unit has a stroke of 16 in.; ram speed ranges are 28½ to 89½ ipm for approach, 4½ to 48 ipm for pressing and 58 to 93 ipm, for return. The change from approach to pressing speed is automatic.

Designing Welded Joints For Dissimilar Steels

- *Engineering characteristics*
- *Service capabilities*
- *Electrode specifications*
- *Temperature conditioning*

By Helmut Thielsch

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A DISSIMILAR-METAL joint consists of a weld deposit having a chemical composition different from the composition of one or several of the adjacent base metals.

Dissimilar-metal weldments are made when two or more different materials are joined by welding. For example, chromium-molybdenum alloy-steel piping may be welded to austenitic stainless-steel pumps, valves or turbine casings. Welds may be required to join certain superalloys to mild, low-alloy or high-alloy steels.

Dissimilar-metal welds have also been used to join components of the same chemical composition. During the last World War, armor-plate steels were extensively welded with austenitic stainless-steel electrodes. Similarly, many low and medium-alloy steels and chromium stainless steels have frequently been welded with austenitic stainless-steel electrodes.

A third important group of dissimilar-metal welds are weld-metal overlays. These usually provide special wear-resisting, corrosion-resisting or heat-resisting properties. The seats of valves used in high-temperature steam service, for example, usually consist of overlays of martensitic stainless steel, Hastelloy, or other special alloy materials. In commercial practice, the metal overlaying is frequently done by submerged-arc welding or inert-gas shielded-arc welding with consumable electrodes.

Dissimilar-metal joints may also be the result of the substitution of materials for others which are not readily available. For example, in a piping system to be fabricated from carbon-molybdenum

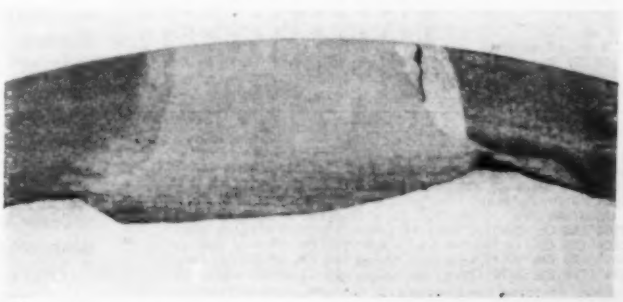


Fig. 1—Crack caused by carbon migration. A carbon-steel repair weld was made in a valve prior to field welding. Although both the valve body and field weld were carbon-molybdenum steel (½ Mo), carbon migration from the repair weld occurred at the 900 F service temperature at which the valve operated

steel piping, valves and fittings of corresponding compositions may not be available in time to meet required delivery schedules. But valves or fittings of somewhat higher alloy content (½ Cr, ½ Mo; or 1¼ Cr, ½ Mo) may be acceptable, depending on service conditions.

Degree of "Dissimilarity": Stainless-steel weld deposits on low-alloy steels obviously would be considered as dissimilar-metal joints. At the other end of the scale, however, differences of as little as ½ or 1 per cent of certain alloying elements may result in considerable variations in properties of the joint. Such joints should also be treated as dissimilar-metal joints.

Illustrated in *Fig.* 1 is a near failure in a repair weld. This weld was made on a carbon-molybdenum steel valve (approx 0.16 C, 0.47 Mo) with a carbon-steel electrode prior to field welding with carbon-molybdenum steel electrodes into a 900 F, 900 psi main steam piping system of a power station. Although the 0.5 per cent molybdenum "dissimilarity" in composition might have been considered negligible, the elevated temperature service caused metallurgical changes across the "dissimilar" bond* and reduced ductility, toughness and creep strength sufficiently to permit initiation and propagation of a crack.

The "dissimilarity" is likely to be more critical between steels of different type compositions than between steels of the same type composition but of different chemical analyses. For example, at temperatures exceeding 800 F the "dissimilarity" between a carbon steel and a carbon, 0.5 per cent molybdenum steel is more critical than the "dissimilarity" between a 1¼ Cr, 0.5 Mo and a 2¼ Cr, 1 Mo alloy steel.

*According to American Welding Society terminology the *bond* is "the junction of the weld metal and the base metal."

Table 1—Filler Metals for Welding Dissimilar Steels: High-Temperature Service

Steel → / Steel	Carbon	Carbon-molybdenum	½ Cr, ½ Mo	1 Cr, ½ Mo	1¼ Cr, ½ Mo	2 Cr, ½ Mo	2¼ Cr, 1 Mo	5 Cr, ½ Mo	7 Cr, ½ Mo	9 Cr, 1 Mo	18 Cr, 8 Ni (Type 304)	18 Cr, 12 Ni (Type 316)	18 Cr, 8 Ni, Cb (Type 347)	25 Cr, 20 Ni (Type 310)
	Filler Metal (see listing below)													
Carbon	–	1	2	2	2	2	3	2	2	2	7	7	7	8
Carbon-molybdenum	1	–	2	2	2	2	3	2	2	2	7	7	7	8
½ Cr, ½ Mo	2	2	–	2	2	2	3	2	2	2	7	7	7	8
1 Cr, ½ Mo	2	2	2	–	2	2	3	3	3	3	7	7	7	8
1¼ Cr, ½ Mo	2	2	2	2	–	2	3	3	3	3	7	7	7	8
2 Cr, ½ Mo	2	2	2	2	2	–	3	3	3	3	7	7	7	8
2¼ Cr, 1 Mo	3	3	3	3	3	3	–	3	3	3	7	7	7	8
5 Cr, ½ Mo	2	2	2	3	3	3	3	–	4	4	7	7	7	8
7 Cr, ½ Mo	2	2	2	3	3	3	3	4	–	5	N	N	N	N
9 Cr, 1 Mo	2	2	2	3	3	3	3	4	5	–	N	N	N	N
18 Cr, 8 Ni (Type 304)	7	7	7	7	7	7	7	7	N	N	–	6	6	8
18 Cr, 12 Ni, Mo (Type 316)	7	7	7	7	7	7	7	7	N	N	6	–	9	8
18 Cr, 8 Ni, Cb (Type 347)	7	7	7	7	7	7	7	7	N	N	6	9	–	8
25 Cr, 20 Ni (Type 310)	8	8	8	8	8	8	8	8	N	N	8	8	8	–

Filler Metals:

Key	Electrodes	Welding Rods
1.	E70XX-A (C, ½ Mo)	C, ½ Mo
2.	E8015-B2, 8016-B2 (1 Cr, ½ Mo)	1 Cr, ½ Mo; 1¼ Cr, ½ Mo
3.	E9015-B3, 9016-B3 (2¼ Cr, 1 Mo)	2 ¼ Cr, 1 Mo
4.	E502 (5 Cr, ½ Mo)	5 Cr, ½ Mo
5.	9 Cr, 1 Mo	9 Cr, 1 Mo
6.	E308 (18 Cr, 8 Ni)	18 Cr, 8 Ni
7.	E309 (25 Cr, 12 Ni)	25 Cr, 12 Ni
8.	E310 (25 Cr, 20 Ni)	25 Cr, 20 Ni
9.	E347 (18 Cr, 8 Ni-Cb)	18 Cr, 8 Ni, Cb

N. Welding of these combinations is not recommended.

Factors Causing Failure: In order for a failure to occur, stresses must be of sufficient magnitude to "tear" apart a material. The greater the "brittleness" of the material, the smaller are the stresses which will cause cracking. Brittleness usually is associated with low ductility and low toughness.

As creep resistance diminishes in the dissimilar-metal joint zone, the stress-level at which cracking will occur also gets lower. This problem may become particularly critical at temperatures above 800 F where metallurgical changes across the dissimilar bond may seriously reduce creep strength in the base metal, the weld metal adjacent to the bond, or in both.

The stress level which causes failure is a combination of various residual and load stresses. This combination includes stresses caused by differences in the coefficient of expansion between the dissimilar materials and, to a lesser extent, differences in the rate of heat transfer. In joints between austenitic stainless steels and ferritic mild or low-alloy steels, the greater coefficient of expansion of the austenitic stainless steels (approximately 50 per cent) may introduce stresses of considerable magnitude. For example, weld assemblies consisting of austenitic stainless-steel weld deposits adjacent to low-alloy steels in service environments exposed to severe thermal fatigue or shock may be distorted. They also may fail due to the initiation and propagation of a crack in the ferritic alloy-steel material which tends to exhibit lower toughness and creep resistance.

In corrosive environments favorable to stress-corrosion cracking, the generally higher stresses across a dissimilar-metal joint tend to increase even further the susceptibility of the joint to stress corrosion and caustic embrittlement.

The presence of surface notches in the dissimilar-metal area further raises the stress level. The consequent higher maximum stress at the root of the notch may be sufficient to permit crack initiation, which requires a greater stress level than the subsequent continued crack propagation.

Most notches are the result of forming, shaping or fabricating operations. Notches can also be formed by pitting because of (1) oxidation as result of heat treatment or elevated temperature service or (2) corrosion as result of excessive pickling or certain corrosive service environments. Weld defects such as lack of root penetration in pipe welds or undercutting also can represent severe notch effects. On the other hand, the effects of small internal porosity and slag inclusion are likely to be negligible.

Other factors to consider are section shape and size. Sharp edges as in tee and corner joints may cause additional stresses. Heavy sections offer

greater restraint and tend to be more susceptible to cracking than light sections.

Metallurgical Effects: The significant metallurgical effects consist of (1) *dilution* of the weld metal during welding and (2) *diffusion* across the dissimilar joint as result of heat treatment or high-temperature service at temperatures exceeding approximately 800 F.

Dilution describes the mixing of the molten welding filler metal being deposited with that portion of the base metal which is melted ("fused") by the welding operation. When the weld is made without the addition of filler metal, the "dilution" would consist of the melting and mixing of portions of the two dissimilar base metals being joined. The amount of dilution varies with the different welding processes and welding conditions. Dilution of the weld by the base metal may be as low as 10 per cent or as high as 60 per cent.

In dissimilar-metal joints between austenitic stainless steels and ferritic carbon or low-alloy steels, a large amount of dilution may produce a rather hard and brittle zone adjacent to the base metal—usually associated by metallurgists with *martensite* formation. The undesirable effects of this may be minimized by careful electrode selection and preheat and postheat treatments.

Diffusion in dissimilar-metal joints describes the movement or migration of atoms across the bond. In steels of dissimilar composition the diffusion of carbon atoms across the bond tends to have the most pronounced effect. *Carbon migration,* as it is usually called, is time and temperature dependent.

At temperatures below 800 F, carbon migration is not considered sufficiently significant to have a harmful effect upon the service properties of the dissimilar-metal joint. With increasing temperatures the diffusion rates increase. Thus, in the average carbon-steel to carbon-molybdenum steel joint at 850 F, the embrittlement may become severe after a period of about 5 to 10 years. But at 950 F, only about 1 year is necessary to cause the same degree of embrittlement. At 1200 F the critical time factor would be reduced to the order of days. From a practical point of view this is not too important, since carbon and carbon-molybdenum steels are rarely used at temperatures exceeding 1000 F. In fact, in high-temperature steam plants, carbon steels are now limited to service below 750 F and carbon-molybdenum steels to service below 800 F. For chemical plants and refinery high-temperature applications, these limits are usually set somewhat higher.

The rate of carbon migration depends also upon the "degree of dissimilarity." It is more rapid from a carbon steel to a 2¼ Cr, 1 Mo steel than to a ½ Cr, ½ Mo or to a carbon-molybdenum steel.

Table 2—Temperature Conditioning: High-Temperature Service

Steel → / Steel	Carbon	Carbon-molybdenum	½ Cr, ½ Mo	1 Cr, ½ Mo	1¼ Cr, ½ Mo	2 Cr, ½ Mo	2¼ Cr, 1 Mo	5 Cr, ½ Mo	7 Cr, ½ Mo	9 Cr, 1 Mo	18 Cr, 8 Ni (Type 304)	18 Cr, 12 Ni, Mo (Type 316)	18 Cr, 8 Ni, Cb (Type 347)	25 Cr, 20 Ni (Type 310)
Temperature Conditions and Heat Treatments (see listing below)														
Carbon	—	B-b	C-c	C-c	D-d	D-d	E-e	E-e	F-e	F-e	A-a	A-a	A-a	A-a
Carbon-molybdenum	B-b	—	C-c	C-c	D-d	D-d	E-e	E-e	F-e	F-e	A-a	A-a	A-a	A-a
½ Cr, ½ Mo	C-c	C-c	—	C-c	D-d	D-d	E-e	E-e	F-e	F-e	C-a	C-a	C-a	C-a
1 Cr, ½ Mo	C-c	C-c	C-c	—	D-d	D-d	E-e	E-e	F-e	F-e	C-a	C-a	C-a	C-a
1¼ Cr, ½ Mo	D-d	D-d	D-d	D-d	—	D-d	E-e	E-e	F-e	F-e	D-a	D-a	D-a	D-a
2 Cr, ½ Mo	D-d	D-d	D-d	D-d	D-d	—	E-e	E-e	F-e	F-e	D-a	D-a	D-a	D-a
2¼ Cr, 1 Mo	E-e	E-e	E-e	E-e	E-e	E-e	—	E-e	F-e	F-e	E-a	E-a	E-a	E-a
5 Cr, ½ Mo	E-e	E-e	E-e	E-e	E-e	E-e	E-e	—	F-e	F-e	E-a	E-a	E-a	E-a
7 Cr, ½ Mo	F-e	F-e	F-e	F-e	F-e	F-e	F-e	F-e	—	F-e	N	N	N	N
9 Cr, 1 Mo	F-e	F-e	F-e	F-e	F-e	F-e	F-e	F-e	F-e	—	N	N	N	N
18 Cr, 8 Ni (Type 304)	A-a	A-a	C-a	C-a	D-a	D-a	E-a	E-a	N	N	—	A-a	A-a	A-a
12 Cr, 12 Ni, Mo (Type 316)	A-a	A-a	C-a	C-a	D-a	D-a	E-a	E-a	N	N	A-a	—	A-a	A-a
18 Cr, 8 Ni, Cb (Type 347)	A-a	A-a	C-a	C-a	D-a	D-a	E-a	E-a	N	N	A-a	A-a	—	A-a
25 Cr, 20 Ni (Type 310)	A-a	A-a	C-a	C-a	D-a	D-a	E-a	E-a	N	N	A-a	A-a	A-a	—

Preheat and Interpass Temperature Conditions

A. Preheating not required (where atmospheric temperatures are below 70 F, the weld joint should be warmed to 100 F prior to welding).

B. On butt welds no preheat required for sections up to ½-in. nominal wall thickness. Sections with ½-in. wall thickness and over should be preheated to 200-400 F.
On fillet welds, no preheating required for any (throat) thickness.
Where atmospheric temperatures are below 70 F, the weld joint should be warmed to 100 F prior to welding.

C. 200-300 F.

D. 300-400 F.

E. 400-500 F.

F. 500-600 F.

N. Welding of these combinations is not recommended.

Postheat Treatments

a. Do not postheat.

b. On butt welds, not required for sections up to ½-in. wall thickness. Sections with over ½-in. wall thickness shall be stress-relieved at 1150 to 1200 F for 1 hr per in. of wall thickness (1 hr min).

c. 1200-1300 for 1 hr per in. of thickness (1 hr min).

d. 1275-1350 for 1 hr per in. of thickness (1 hr min).

e. 1300-1375 for 1 hr per in. of thickness (1 hr min).

Table 3—Filler Metals for Welding Dissimilar Steels: Normal and Intermediate-Temperature Service

Steel → / Steel	Ref.*	Mn	2½ Ni	3½ Ni	Mo (4035)	Ni, Cr (3120)	Ni, Cr (3135)	Ni, Cr (3315)	½ Cr, ½ Mo	1¼ Cr, ½ Mo	2¼ Cr, 1 Mo	5 Cr, ½ Mo	Type 304	Type 304L	Type 309	Type 310	Type 316	Type 321	Type 347	Type 410	Type 420	Type 405	Type 430
		Examples of Recommended Filler Metals for Service at Temperatures Not Exceeding 800 F (see listing below)																					
Carbon	–	1	12	12,13	1,2,10	2	2	12,13	1 2	2	2	2	19,20	19,20	19,20	19,20	19,20	19,20	19,20	2	2	2	2
Carbon, ½ Mo	–	1	12	12,13	10	10	10	12,13	10	10	10	10	19,20	19,20	19,20	19,20	19,20	19,20	19,20	11	11	11	11
Mn	1	—	12	12,13	3,4,10	3,4	12	12,13	3,4	4	4	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	4	4	4	4
2½ Ni	1	12	—	12,13	12	12	12	12,13	12	12	12	12	19,20	19,20	19,20	19,20	19,20	19,20	19,20	—	—	—	—
3½ Ni	1	12,13	12,13	—	12,13	12,13	12,13	13	12,13	12,13	12,13	12,13	19,20	19,20	19,20	19,20	19,20	19,20	19,20	—	—	—	—
Mo (4035)	2	3,4,10	12	12,13	—	10	10	12,13	10	10	10	10	19,20	19,20	19,20	19,20	19,20	19,20	19,20	—	—	—	—
Ni, Cr (3120)	2	3,4	12	12,13	10	—	5,6,7,8	12,13	—	—	—	—	19,20	19,20	19,20	19,20	19,20	19,20	19,20	—	—	—	—
Ni, Cr (3135)	2	12	12	12,13	10	5,6,7 8	—	12,13	—	—	—	—	19,20	19,20	19,20	19,20	19,20	19,20	19,20	—	—	—	—
Ni, Cr (3315)	2	12,13	12,13	13	12,13	12,13	12,13	—	—	—	—	—	19,20	19,20	19,20	19,20	19,20	19,20	19,20	—	—	—	—
Mn, Ni, Mo (8620)	2	3,4	12	12,13	3,4,10	3,4	3,4	12,13	—	—	—	—	19,20	19,20	19,20	19 20	19,20	19,20	19,20	—	—	—	—
½ Cr, ½ Mo	3	3,4	12	12,13	10	—	—	—	—	14,15	15	15	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	14,15	14,15	14,15	14,15
1¼ Cr, ½ Mo	3	4	12	12,13	10	—	—	—	14,15	—	15	15	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	15	15	15	15
2¼ Cr, 1 Mo	3	4	12	12,13	10	—	—	—	15	15	—	16	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	16	16	16	16
5 Cr, ½ Mo	3	4	12	12,13	10	—	—	—	15	15	16	—	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	19,20,21	17	17	17	17
Type 304	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	—	18	18	18	18	18	18	19,20	19,20	19,20	19,20
Type 304L	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	18	—	19	20	22	23	23	19,20	19,20	19,20	19,20
Type 309	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	18	19	—	19	19	23	23	19,20	19,20	19,20	19,20
Type 310	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	18	20	19	—	22	23	23	20	20	20	20
Type 316	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	18	22	19	22	—	22 23	22,23	19,20	19,20	19,20	19,20
Type 321	4	19 20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	18	23	23	23	22,23	—	23	19,20	19,20	19,20	19,20
Type 347	4	19,20	19,20	19,20	19,20	19,20	19,20	19,20	19,20,21	19,20,21	19,20,21	19,20,21	18	23	23	23	22,23	23	—	19,20	19,20	19,20	19,20
Type 410	5	4	—	—	—	—	—	—	14,15	15	16	17	19,20	19,20	19,20	20	19,20	19,20	19,20	—	24	24	24
Type 420	5	4	—	—	—	—	—	—	14,15	15	16	17	19,20	19,20	19,20	20	19,20	19,20	19,20	24	—	25	25
Type 405	6	4	—	—	—	—	—	—	14,15	15	16	17	19,20	19,20	19,20	20	19,20	19,20	19,20	24	25	—	25
Type 430	6	4	—	—	—	—	—	—	14,15	15	16	17	19,20	19,20	19,20	20	19,20	19,20	19,20	24	25	25	—

*Steels given correspond to alloys listed in: (1) "Wrought Carbon and Alloy Steel: Weldability," May, 1955, Table 2; (2) Ibid, Table 4; (3) Ibid, Table 5; (4) "Weldability of Stainless Steel," June, 1955, Table 2; (5) Ibid, Table 4; (6) Ibid, Table 5.

Filler Metals:

Type	Key	Covered Electrode	Welding Rod or Bare Electrode
Carbon steel	1	E60XX	Carbon steel
	2	E6015, E6016	Carbon steel
Low-alloy steel	3	E70XX	Proprietory, producing weld deposits of tensile strengths corresponding to AWS EXXXX electrodes
	4	E7015, E7016	
	5	E80XX	
	6	E8015, E8016	
	7	E90XX	
	8	E9015, E9016	
	9	E10015, E10016	
Carbon-molybdenum steel	10	E70XX-A1	C, ½ Mo
	11	E7015-A1, E7016-A1	C, ½ Mo
Nickel steel	12	EXX15-C1, EXX16-C1	2½ Ni
	13	EXX15-C2, EXX16-C2	3½ Ni

Filler Metals:

Type	Key	Covered Electrode	Welding Rod or Bare Electrode
Chromium-molybdenum steel	14	EXX15-B1, EXX16-B1	½ Cr, ½ Mo
	15	EXX15-B2, EXX16-B2	1 Cr, ½ Mo
	16	EXX15-B3, EXX16-B3	2 Cr, 1 Mo
	17	E502	5 Cr, ½ Mo
Austenitic stainless	18	E308	ER308
	19	E309	ER309
	20	E310	ER310
	21	E312	ER312
	22	E316	ER316
	23	E347	ER347
Martensitic stainless	24	E410	ER410
Ferritic stainless	25	E430	ER430

The direction of carbon migration usually is from the lower alloy to the higher alloy steel. More precisely, the carbon atoms migrate towards the steel containing the stronger carbide-forming elements or the greater quantity of them.

Service Temperatures Above 800 F: In service applications above 800 F, where the metallurgical changes taking place may have a significant effect upon the service life of the joint, it is particularly important to select welding filler metals which minimize the possible detrimental effects associated with carbon migration.

Recommendation for welding the more commonly used high-temperature steels are given in *Table* 1 for filler metal selection and in *Table* 2 for preheat and postheat treatments.

These recommendations represent average practice only. Unusual or extremely severe high-temperature service conditions, may require special consideration. For example, an Inconel A electrode has shown some promise in weld joints between Type 347 stainless steels and the 1¼ Cr, ½ Mo and 2¼ Cr, 1 Mo alloy-steel grades under severe thermal conditions—such as thermal fatigue or cyclic quenching and heating between 1000-1100 and 75-300 F. Since, at this time, high-temperature service data are not available for periods exceeding 1 year, the specification of this particular alloy should be made with extreme caution.

Design engineers in selecting materials on the basis of test data must always recognize that no test, however severe, is identical to actual service conditions. For example, creep tests may indicate a material to be excellent for high-temperature service. However, during service the material fails unexpectedly because the design, size, or metallurgical changes taking place introduce additional factors which could not be predicted from the small-section creep tests alone.

Service Temperatures Below 800 F: In structural fabrication and construction and in pressure vessel and pressure piping applications where corrosion is not a consideration, selection of the welding filler metal should be made on the basis of the strength of the base metal. As a general rule an

Table 4—Temperature Conditioning: Normal and Intermediate-Temperature Service

Steel	Ref.*	Mn	2½ Ni	3½ Ni	Mo (4035)	Ni, Cr (3120)	Ni, Cr (3135)	Ni, Cr (3315)	½ Cr, ½ Mo	1¼ Cr, ½ Mo	2¼ Cr, 1 Mo	5 Cr, ½ Mo	Type 304	Type 304L	Type 309	Type 310	Type 316	Type 321	Type 347	Type 410	Type 420	Type 405	Type 430
Steel →																							
Temperature Conditions and Heat Treatments (see listing below)																							
Carbon	–	B-b	G-b	H-b	E-b	E-b	F-b	F-b	C-c	H-d	I-e	F-e	A-a	A-a	A-a	A-a	A-a	A-a	A-a	E-e	E-e	A-e	A-e
Carbon, ½ Mo	–	B-b	G-b	H-b	E-b	E-b	F-b	F-b	C-c	H-d	I-e	F-e	A-a	A-a	A-a	A-a	A-a	A-a	A-a	E-e	E-e	A-e	A-e
Mn	1	—	G-b	H-b	E-b	E-b	F-b	F-b	D-c	H-d	I-e	F-e	A-g	A-g	A-g	A-g	A-g	A-g	A-g	E-e	E-e	A-e	A-e
2½ Ni	1	G-b	—	H-b	I-b	I-b	F-b	F-b	D-c	H-d	I-e	F-e	G-g	G-g	G-g	G-g	G-g	G-g	G-g	—	—	—	—
3½ Ni	1	H-b	H-b	—	I-b	I-b	F-b	F-b	D-c	I-d	I-e	F-e	H-g	H-g	H-g	H-g	H-g	H-g	H-g	—	—	—	—
Mo (4035)	2	E-b	I-b	I-b	—	E-b	F-b	F-b	E-c	I-d	I-e	F-e	I-g	I-g	I-g	I-g	I-g	I-g	I-g	—	—	—	—
Ni, Cr (3120)	2	E-b	I-b	I-b	E-b	—	F-b	F-b	E-c	I-d	I-e	F-e	H-g	H-g	H-g	H-g	H-g	H-g	H-g	—	—	—	—
Ni, Cr (3135)	2	F-b	F-b	F-b	F-b	F-b	—	F-b	F-c	F-d	F-e	F-e	F-g	F-g	F-g	F-g	F-g	F-g	F-g	—	—	—	—
Ni, Cr (3315)	2	F-b	F-b	F-b	F-b	F-b	F-b	—	F-c	F-d	F-e	F-e	F-g	F-g	F-g	F-g	F-g	F-g	F-g	—	—	—	—
Mn, Ni (8620)	2	D-b	H-b	H-b	E-b	E-b	F-b	F-b	F-c	F-d	F-e	F-e	G-g	G-g	G-g	G-g	G-g	G-g	G-g	—	—	—	—
½ Cr, ½ Mo	3	D-c	H-c	H-c	E-c	E-c	F-c	F-c	—	D-d	E-e	F-e	G-g	G-g	G-g	G-g	G-g	G-g	G-g	E-e	E-e	D-e	D-e
1¼ Cr, ½ Mo	3	H-d	H-d	I-d	I-d	I-d	F-d	F-e	D-d	—	E-e	F-e	G-g	G-g	G-g	G-g	G-g	G-g	G-g	E-e	E-e	H-e	H-e
2¼ Cr, 1 Mo	3	I-e	I-e	I-e	I-e	I-e	F-e	F-e	E-e	E-e	—	F-e	H-g	H-g	H-g	H-g	H-g	H-g	H-g	E-e	E-e	I-e	I-e
5 Cr, ½ Mo	3	F-e	F-e	F-e	F-e	F-e	F-e	F-e	F-e	F-e	F-e	—	H-g	H-g	H-g	H-g	H-g	H-g	H-g	E-e	E-e	F-e	F-e
Type 304	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	—	A-f	A-f	A-f	A-f	A-f	A-f	E-e	E-e	A-e	A-e
Type 304L	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	A-f	—	A-f	A-f	A-f	A-f	A-f	E-e	E-e	A-e	A-e
Type 309	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	A-f	A-f	—	A-f	A-f	A-f	A-f	E-e	E-e	A-e	A-e
Type 310	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	A-f	A-f	A-f	—	A-f	A-f	A-f	E-e	E-e	A-e	A-e
Type 316	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	A-f	A-f	A-f	A-f	—	A-f	A-f	E-e	E-e	A-e	A-e
Type 321	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	A-f	A-f	A-f	A-f	A-f	—	A-f	E-e	E-e	A-e	A-e
Type 347	4	A-g	G-g	H-g	I-g	H-g	F-g	F-g	G-g	G-g	H-g	H-g	A-f	A-f	A-f	A-f	A-f	A-f	—	E-e	E-e	A-e	A-e
Type 410	5	E-e	—	—	—	—	—	—	E-e	E-e	E-e	E-e	E-g	E-g	E-g	E-g	E-g	E-g	E-g	—	J-e	A-e	A-e
Type 420	5	E-e	—	—	—	—	—	—	E-e	E-e	E-e	E-e	E-g	E-g	E-g	E-g	E-g	E-g	E-g	J-e	—	A-e	A-e
Type 405	6	A-e	—	—	—	—	—	—	D-e	H-e	I-e	F-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	—	A-e
Type 430	6	A-a	—	—	—	—	—	—	D-e	H-e	I-e	F-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	A-e	—

Preheat and Interpass Temperature Conditions

A. Preheating not required. Where atmosphere temperatures are below 70 F, the weld joint should be warmed to 100 F prior to welding.
B. EXXXX electrodes, preheat up to 200 F. EXX15 and EXX16 electrodes and bare welding rods, preheating not required.
C. EXXXX electrodes, preheat to 100-300 F. EXX15 and EXX16 electrodes and bare welding rods, preheating not required.
D. EXXXX electrodes, preheat to 200-400 F. EXX15 and EXX16 electrodes and bare welding rods, preheat to 200 F.
E. EXXXX electrodes, preheat to 300-500 F. EXX15 and EXX16 electrodes and bare welding rods, preheat to 100-500 F.
F. EXXXX, EXX15 and EXX16 electrodes, preheat to 400-600 F.
G. Preheat to 150-350 F.
H. Preheat to 200-400 F.
I. Preheat to 300-500 F.
J. Preheat to 600-700 F.

Postheat Treatment

a. Do not postheat.
b. 1100-1250 F for 1 hr per in. of thickness (1 hr min)
c. 1200-1300 F for 1 hr per in. of thickness (1 hr min)
d. 1275-1350 F for 1 hr per in. of thickness (1 hr min)
e. 1325-1400 F for 1 hr per in. of thickness (1 hr min)
f. Necessity for a postheat treatment depends upon the intended service.
g. Do not postheat unless service is in environments tending to cause stress-corrosion cracking, in which case postheat to 1250-1300 F for 1 hr per in. of thickness.

Note: EXXXX electrodes include covering tynes EXX10, EXX11, EXX12, EXX13, EXX20, EXX24, EXX27 and EXX30.

electrode or welding rod should be selected in accordance with the recommendations given for various steel groupings in the first article of this series (May, 1955, Page 166).

When two steels of different strength characteristics are being joined, it is usually sufficient to specify the electrode recommended for the lower-strength material. Typical recommendations for various groupings of dissimilar-metal combinations are given in *Table* 3. For example, in a joint between an AISI 4035 steel requiring an E80XX electrode and an AISI 3145 steel requiring an E100XX electrode, the E80XX electrode generally would be satisfactory. However, preheat and postheat treatments should be selected in accordance with the recommendations given for the higher strength steel (i.e., in the above example for the 3145 steel). Typical heat treatment recommendations are summarized in *Table* 4.

An example of dissimilar-metal joint considered extremely difficult about a decade ago is shown in *Fig.* 2 between a Type 410 stainless-steel tube and carbon-steel jacketing for very high-pressure service. The jacketing is for Dowtherm cooling of the high-pressure system. The weld was made with AWS E6010 electrodes at the preheat of 400-500 F.

In dissimilar-metal joints between alloy steels and austenitic stainless steels, Type 309 (25 Cr, 12 Ni), Type E310 (25 Cr, 20 Ni), or Type E312 (29 Cr, 9 Ni) stainless-steel electrodes are most commonly used. On these joints, the low-alloy steel should be preheated and postheated in accordance with the previously mentioned recommendations for the more common alloy-steel materials. It is not desirable to weld austenitic stainless steels with mild or low-alloy steel (nonaustenitic) filler metals. Dilution would tend to make the resulting welds rather brittle.

Until about 5 to 10 years ago, some of the more highly alloyed hardenable steels, such as armorplate steels and chromium-molybdenum pipe steels for refinery applications, have frequently been welded with austenitic stainless-steel electrodes. With the development of low-hydrogen electrode coverings, this is no longer considered desirable practice, since high-quality welds can be readily obtained with low-alloy steel electrodes. The use of austenitic stainless-steel electrodes, therefore, should generally be limited to weld joints consisting of at least one stainless-steel member.

SUBZERO TEMPERATURE APPLICATIONS: In service applications at subzero temperatures where notch-resistant carbon, low-alloy and nickel steels are used, the filler metal and preheat and postheat conditions should generally be the same as recommended for the more highly alloyed steel. Where nickel steels are to be welded, a nickel-steel filler metal should be used; for example, EXX15-C1 or EXX15-C2 electrodes. In joints between carbon, low-alloy, and nickel steels on one side and austenitic stainless steels on the other, either 25 Cr, 12 Ni (Type 309) or 25 Cr, 20 Ni (Type E310) filler metals are recommended.

CORROSION SERVICE: In corrosive service environments dissimilar-metal joints are relatively uncommon. Many dissimilar-metal combinations, upon contact with an electrolyte, tend to corrode along the anodic side of the joint.

Susceptibility to this galvanic corrosion varies with the corrosiveness of the solution and the "dissimilarity" of the materials involved, as related to their relative position in the galvanic series. In weak solutions the "dissimilarity," for example, between a 1¼ Cr, ½ Mo and a 5 Cr, ½ Mo steel may have a negligible effect upon galvanic corrosion, provided that the proper 1¼ Cr, ½ Mo alloy-steel electrode is used (*Table* 3). In corrosive applications extreme care must be exercised in the selection of the proper electrode. The "degree of dissimilarity" must not be increased by choosing "unknown" electrodes of higher or lower alloy composition.

STRESS-CORROSION APPLICATIONS: In environments causing stress corrosion, the higher residual stresses which may remain across the weld between materials having dissimilar coefficients of expansion may increase the susceptibility of the material

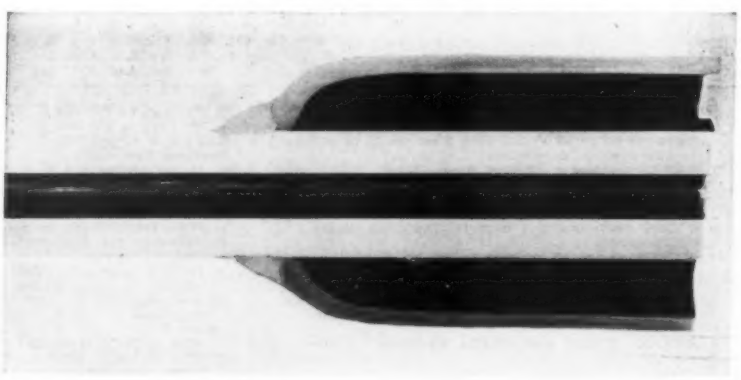


Fig. 2—Dissimilar-metal joint between carbon-steel jacketing welded to Type 410 stainless - steel

to stress-corrosion cracking. In such an application, proper preheating and stress relieving is very important. This applies also to joints between austenitic stainless steels and carbon or low-alloy steels. The coefficient of expansion of austenitic stainless steel is approximately 50 per cent higher than the coefficient of carbon or low-alloy steels. Stress relieving of joints involving austenitic stainless steel is not ordinarily recommended. But in stress-corrosion environments the service life of such a weldment is usually increased considerably by properly preheating and stress relieving the welded section.

Summary: Typical recommandations are given in *Table* 3 for filler metal selection and in *Table* 4 for preheat and postheat treatments. Of course, many other combinations are also possible, depending upon the materials involved or upon the service environment.

For example, in the application shown in *Fig.* 2, Type 410 stainless-steel tubing was initially Roto-rolled (i.e., cold reduced) to exhibit a yield strength of 95,000 psi. In the annealed condition the yield strength would have been about 40,000 psi. To avoid softening of the Type 410 tubing, postheating after welding was omitted. Moreover, this application also required careful control over interpass temperature, electrode size and welding conditions. This example typifies the careful consideration—and also the possible exceptions—which may be necessary in welding dissimilar metals.

BIBLIOGRAPHY

This article is the sixth in a co-ordinated group by Helmut Thielsch on welding and weldments. Previous articles, and issues of MACHINE DESIGN in which they appeared, are:

Wrought Carbon and Alloy Steel: Weldability . . . . . May, 1955
Weldability of Stainless Steel . . . . . June, 1955
Weldability of Cast Steels . . . . . July, 1955
Selecting Electrodes and Welding Rods:
Part 1—Mild and Low-Alloy Steels . . . . . Sept., 1955
Part 2—Stainless Steels . . . . . Dec., 1955

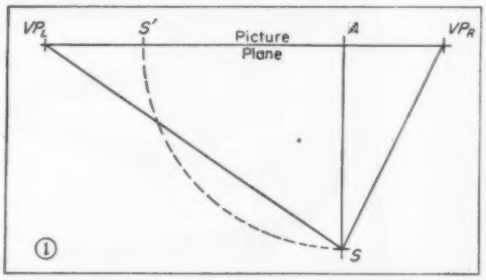
Tips and Techniques

Vertical Foreshortening In Angular Perspective

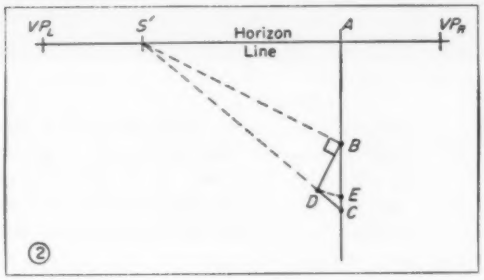
IN ANGULAR (two-point) perspective, dimensions measured above and below the horizon line are actual scaled dimensions. No allowance is made for vertical foreshortening as in three-point perspective. Thus, finished objects drawn much above or below eye level appear too tall.

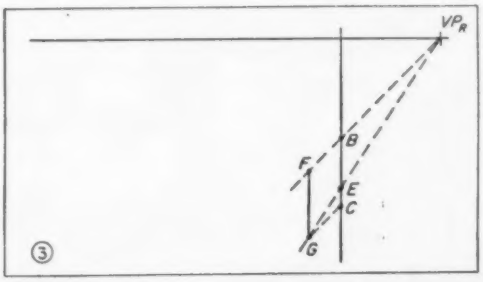
A technique which is easier than going to three-point perspective is to adjust vertical spacing by approximate foreshortening. It should be used only when objects are drawn well below or above the horizon, since vertical foreshortening is not needed near the eye-level line. All heights can be drawn to scale. The method is:

1. Rotate *S* to the picture plane around *A*, *Fig.* 1.
2. Draw lines of sight from the rotated position, *S'* in *Fig.* 2, to points *B* and *C*, which represent true scale heights of the object to be drawn.
3. Draw *BD*, with *S'BD* as a 90-degree angle.
4. Transfer *BD* to *BE* by rotating around *B*. Distance *BE* then represents the foreshortened height originally scaled off as *BC*.



A vertical measuring line can be established, *Fig.* 3, so that heights can be scaled off directly. Lines are drawn from one of the vanishing points through *B* and *E*. A parallel through *C* then establishes *FG*, which is equivalent to *BC* in length and represents the true scaled height of the object.





Actual distances can be scaled on *FG* and projected back to *BE* by running a line through the proper vanishing point. — ELMO L. REYNOLDS, *American Kitchens Div., Avco Mfg. Corp., Connersville, Ind.*

A similar method for foreshortening verticals in two-point perspective is shown in *Fig.* 5 and associated text of "Perspective Drawings" by F. W. Reighard, MACHINE DESIGN, Nov., 1955, Page 151—ED.

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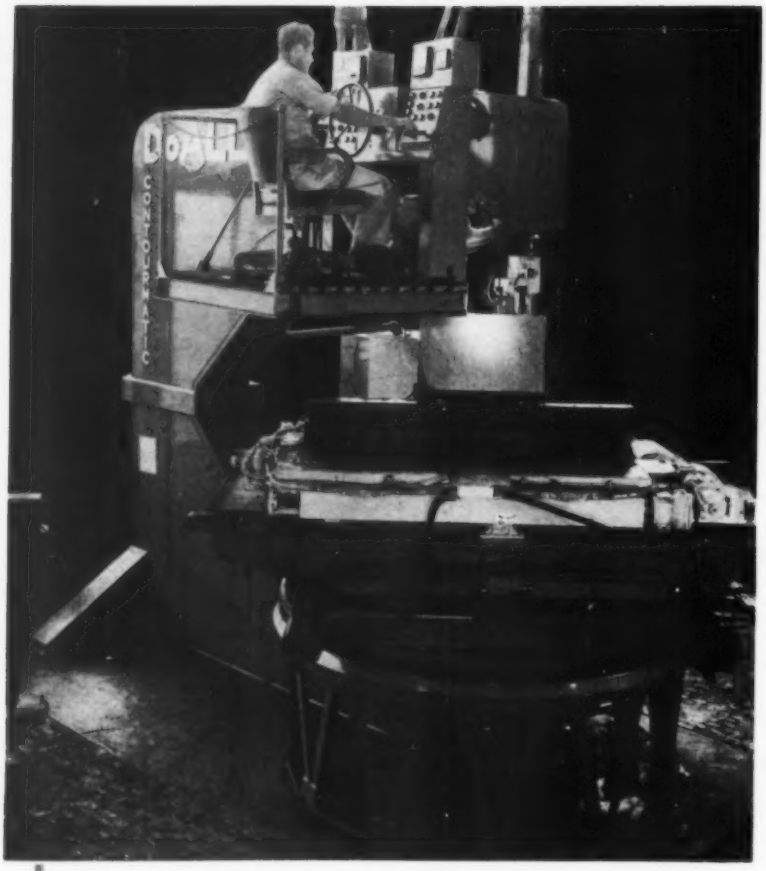
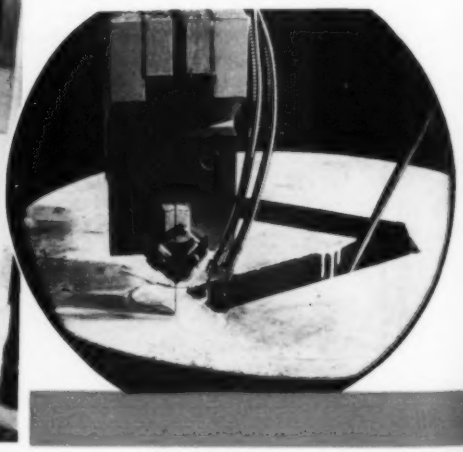


—Operator

A NEW bandsaw, claimed to be the world's largest, produces extrusion dies for use on giant extrusion presses used to make aircraft parts. Designed and built by the DoAll Co., the huge bandsaw is 15 feet, 10 inches high and occupies an area 21 by 17 feet. Work pieces up to 26 inches thick and 52 inches in diameter can be handled. Weight of a piece of steel this size would be approximately 10 tons.

Guiding such a large piece with normal feeding devices would be impossible considering the required accuracy. To provide the necessary controlled movement, a unique electrohydraulic system is used to move the workpiece in synchronization with a control wheel which might be compared to an aircraft control wheel. In addition to controlling cutting direction, inward or outward motion of the control wheel varies the rate of infeed or outfeed of the work piece to the saw blade.

The operator's control station is mounted on the upper arm of the C-shaped machine



Steers Big Band Saw

frame and can be manually swung through a 90-degree arc for best positioning with respect to the workpiece. Raising or lowering of the operator's platform to provide the best view of the workpiece is also possible. Push-buttons to control raising and lowering of the platform as well as all other machine controls are mounted on the platform.

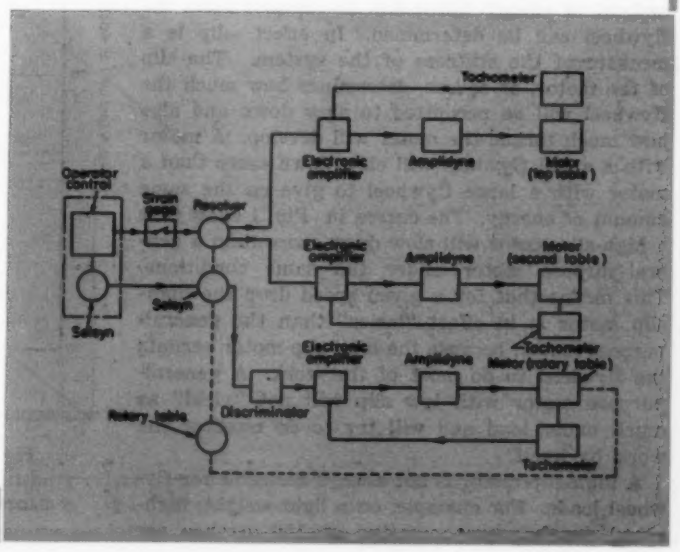
A periscope-like arrangement of mirrors is used to give the operator a close-up view of workpiece and saw blade as work progresses. Head and eyes of the operator are actually quite a distance from the workpiece and blade. This reduces operator hazard.

Proper work piece motion is provided by three tables mounted one above the other. The lowest table rotates, and its axis of rotation coincides with the axis of the saw-blade teeth. The two top tables move linearly with their directions of motion perpendicular to each other. Since motion of the lqwest table is purely rotary it imparts no feed motion to the workpiece. Combined motions of the two upper tables are controlled to result in a feed motion which is always directly into the saw teeth regardless of table rotation.

As the operator moves the control wheel forward to initiate work feed, a potentiometer is operated to provide a voltage proportional to control movement. This voltage is then fed to a resolver whose position corresponds to control-wheel and rotary-table position. The resolver outputs are two voltages. One is equal to the incoming voltage times the sine of the angle of the rotary table and the other is equal to the incoming voltage times the cosine of the angle. These voltages are then fed to electronic amplifiers, amplidyne motor generator sets and dc drive motors to produce the proper feed rate for each table. Table feed motors also drive small tachometer-type generators whose outputs are fed back to the electronic amplifiers and compared with the input signals from the resolver. If drive motor speed is not correct, the necessary correction in amplifier output is then made.

As the control wheel is rotated, a selsyn on the shaft also rotates. Output of a connected selsyn which is mechanically connected to the rotary table varies in proportion to this movement. This output is fed to a discriminator, amplifier, amplidyne and dc drive motor to rotate the table and connected selsyn until their position corresponds to that of the control wheel-actuated selsyn. Again a tachometer generator is used as a feedback device to maintain correct rotational speed.

Since the operator does not touch the work during cutting operations, he is unable to evaluate cutting pressure, ease of cutting, rate of cutting, etc., by feel. Strain gages and an indicator inform the operator of cutting pressures at all times. Additionally, strain gage output is used to modify input to the resolver and table feeds so that the value of feed pressure set by the operato. will not be exceeded. Additional control elements stop the feed if cutting or feed forces become excessive.



Contemporary Design

Selecting AC Motors

. . . for flywheel applications

By C. G. Helmick
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ON A PULSATING load with high torque values of short duration, it would not be economical to select a motor capable of delivering peak torque requirements. Obviously, the motor would be fully loaded only for a short period of time, and would be practically unloaded for the remainder of the time. However, if a flywheel with sufficient stored energy is used, the flywheel inertia can supply the high peak-torque requirements by slowing down slightly to release some of its stored energy. Then the drive motor need be only large enough to replenish the flywheel's lost energy over the balance of the cycle.

Motor Slip: Thus some of the factors which influence the selection of both motor and flywheel become apparent. If the amount of the flywheel inertia and the slip of the motor are known, the amount of energy which will be released from the flywheel can be determined. In effect, slip is a measure of the stiffness of the system. The slip of the motor, of course, determines how much the flywheel will be permitted to slow down and also how much torque the motor will develop. A motor with a small flywheel will slow down more than a motor with a large flywheel to give up the same amount of energy. The curves in *Fig.* 1 show that a high-slip motor will slow down more than a general-purpose motor under the same conditions. This means that for a given speed drop the high-slip motor is in effect "lazier" than the general-purpose motor, because the high-slip motor permits the flywheel to do most of the work. A general-purpose motor with low slip will not "yield" as much under load and will try to do most of the work by itself.

A high-slip motor is not always desirable for flywheel loads. For example, on a light-weight, high-speed punch press operating at 150 strokes per minute, the time for each stroke of the press is so short that there is not enough time for a flywheel to slow down and then reaccelerate. The recommended motor for this application is one with ordinary low-slip characteristics. The motor, of course, would have to be selected to carry the peak torque requirements with ample margin to prevent exceeding the motor breakdown torque. Of course, the motor must also be capable of carry-

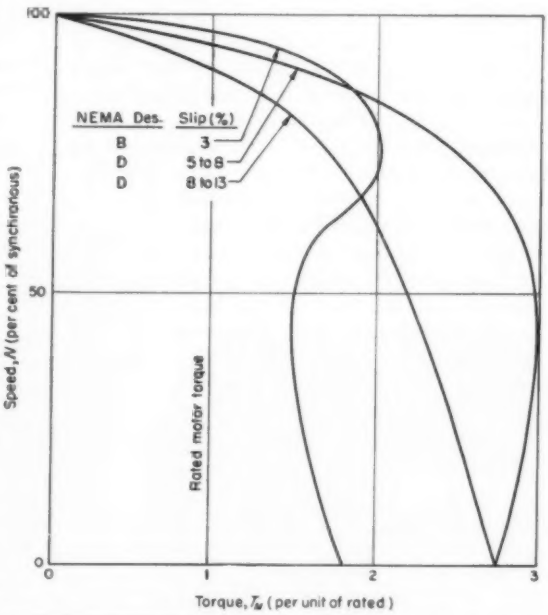


Fig. 1 — Typical speed-torque characteristics for NEMA Design B and D motors. Slip values given are at rated torque

ing the thermal load imposed by this duty cycle.

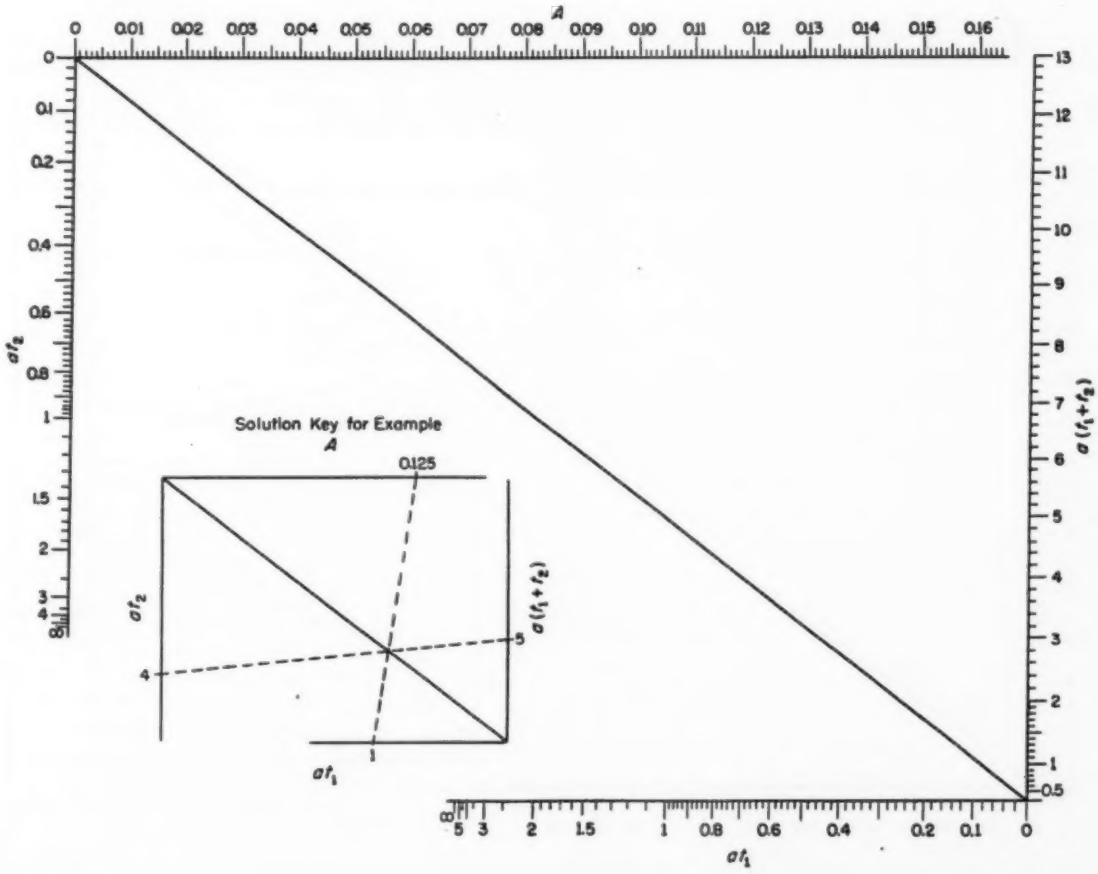
However, the high-slip motor has features which make it desirable for a great many applications of this nature. In addition to the ability of the high-slip motor to "yield" with a sudden application of load, this motor has a second advantage of not having a clearly defined breakdown point on its speed-torque curve, *Fig.* 1. Thus, breakdown torque is not a problem.

Specifications: The high-slip motor is known as NEMA Design D. Specifications say this motor shall have a full-load slip in excess of 5 per cent and shall develop a starting torque of 275 per cent of rated. The starting current of a high-slip motor is generally about the same as for the general-purpose motor. This NEMA specification has been loosely drawn intentionally because of the somewhat special nature of applications of this motor. Motor manufacturers have taken advantage of this latitude by developing two classes of NEMA Design D motors. The first class has a full-load slip between 5 and 8 per cent while the other class has a full-load slip between 8 and 13 per cent. The

Table 1—Comparison of Motor Frame Sizes

Motor Power (hp)	Sync. Speed (rpm)	NEMA Frame Size—OPEN Gen Pur.	5-8%	8-13%	NEMA Frame Size—TEFC—55 C Gen. Pur.	5-8%	8-13%
5	1800	254	254	254	254	284	324
	1200	284	284	324	284	324	326
	900	324	324	326	324	326	326
7½	1800	284	284	324	284	324	326
	1200	324	324	326	324	326	364
	900	326	326	365	326	365	365
10	1800	324	324	326	324	326	364
	1200	326	326	365	326	364	365
	900	364	365	404	364	404	405
15	1800	326	326	365	326	365	365
	1200	364	365	404	364	404	405
	900	365	404	405	365	444	444
20	1800	364	364	404	364	404	404
	1200	365	404	405	365	444	444
	900	404	405	444	404	445	445
25	1800	364	365	404	365	444	444
	1200	404	405	444	404	445	445
	900	405	444	445	405	504	505
30	1800	365	404	405	404	445	445
	1200	404	444	445	405	504	505
	900	444	445	504	444	505	607
40	1800	404	405	444	405	504	504
	1200	444	445	504	444	505	607
	900	445	504	505	445	607	...
50	1800	405	444	445	444	...	...
	1200	445	504	505	445	505	505
	900	504	505	580	504	...	...

Fig. 2—Nomograph to evaluate constant A. This constant is used in Equation 8 to calculate per unit rms motor torque, ${}_uT_{Mrms}$



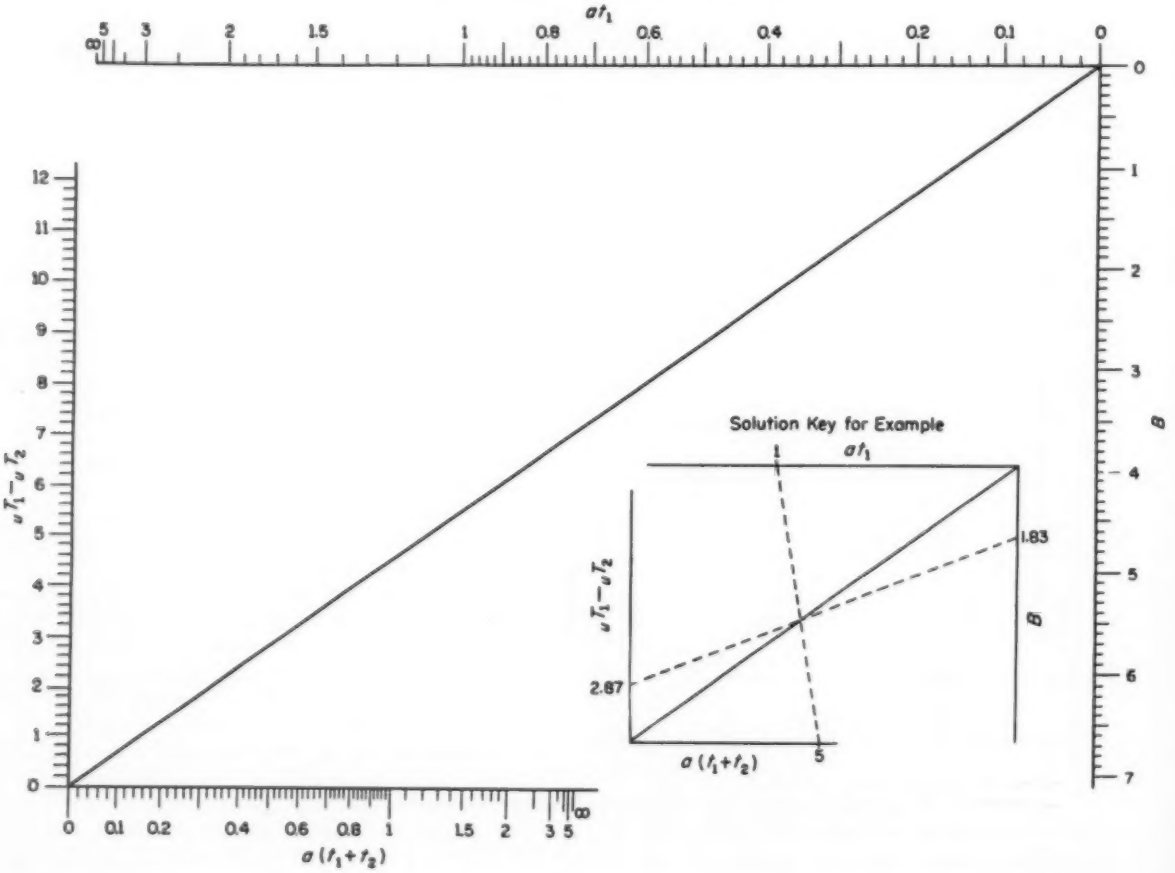
characteristic curves for both of these motors are shown in *Fig.* 1. These curves permit refinement in matching the motor and the load characteristics.

Efficiency: The construction of the high-slip motor is the same as for a general-purpose induction motor. The difference lies primarily in the rotor design. By using rotor bars made of brass, bronze or other high-resistance alloys, the speed-torque characteristics can be made to droop more, resulting in a higher full-load slip. This is somewhat similar to adding resistance to the secondary of a wound-rotor motor. Both the high resistance and high slip result in much higher rotor losses than normally occur with a general-purpose motor. Thus the efficiency of high-slip motors is usually substantially less than of a general-purpose motor. For this reason a high-slip motor is seldom used where it will be called upon to operate at steady speeds for any great length of time.

Frame Size: A secondary point to consider is that a high-slip motor has a rated speed which may be as much as 10 per cent lower than a general-purpose motor. Thus, to deliver the same horsepower, the high-slip motor must develop greater full-load torque. This factor combined with increased motor losses usually results in the use of a larger frame-size machine, especially in the case of enclosed motors. The higher the slip, the larger the frame size. This is shown in *Table* 1 which compares frame sizes for general-purpose motors, 5 to 8 per cent slip motors and 8 to 13 per cent slip motors in the 5 to 50-horsepower range. This table furnishes background for the proper application of these motors.

Duty Cycle: The nature of the load cycle will, of course, be the most important single factor in the selection of the proper motor. Load cycle includes the peak torque requirements, their duration, and the load during the balance of the cycle. This immediately sets some limitations on the motor to be applied. For example, it is obvious that the motor must be at least large enough to carry the average torque requirements of the load. At the other extreme the motor will not have to be larger than that required to meet the rms load-torque requirement. In a good many cases, however, this range is fairly large—often too large to permit selection of the proper motor on this

Fig. 3—Nomograph to evaluate constant *B*. This constant is used in Equation 9 to calculate per unit peak motor torque, $_{u}T_{1}$



basis alone. The objective in selecting the proper motor is to get the combination of flywheel inertia and slip which will load a motor thermally to its rated value and at the same time keep the motor below the breakdown torque value.

Solution Technique: This problem of finding proper motor and flywheel size has been analyzed mathematically, and while it is not a simple problem by any means, the solution may be obtained rather quickly by a straight-forward trial-and-error process. The nomograms in *Figs.* 2 and 3 have been developed to simplify the process of solution.

The usual approach to a problem is to define the load requirements and then proceed to select the necessary inertias for 5 to 8 per cent slip, 8 to 13 per cent slip, and general purpose low-slip motors. In this way, a comparison of total motor-flywheel cost may be summarized, along with any other factors to be considered, such as frame size and energy losses. In this way an intelligent selection can be made based on optimum performance and sound engineering economics.

The following example will illustrate the solution method.

Example: Assume a machine has a load cycle such as depicted in *Fig.* 4. This load cycle consists of a 375 lb-ft torque of 2 seconds duration and a 30 lb-ft torque of 8 seconds. Find flywheel inertia and motor size and type that will most satisfactorily and economically handle this load.

As discussed previously the motor must be large enough to carry average torque requirements of the load but needs to be no larger than required to meet the rms torque load requirements for the cycle. Therefore, first calculate the average torque required from Equation 1, or

$$T_{avg} = \frac{2(375) + 8(30)}{10} = 99 \text{ lb-ft}$$

and rms torque from Equation 2, which gives

$$T_{rms} = \sqrt{\frac{2(375)^2 + 8(30)^2}{10}} = 170 \text{ lb-ft} .$$

If a particular motor speed is selected, the range of acceptable motor horsepowers can be calculated. If a motor with a rated speed of about 1750 rpm is being considered, the average motor horsepower calculated on the basis of Equation 3 is $P_{avg} = 99\ (1750)/5250 = 33$ hp. Similarly, the value of rms motor horsepower from Equation 4 shows $P_{rms} = 170\ (1750)/5250 = 57$ hp. These calculations indicate the motor definitely must be larger than 33 hp, but certainly less than 57 hp. Therefore, try a 40-hp motor. To use the curves in

Nomenclature

A = Constant defined by Equation 7
a = Constant defined by Equation 6
B = Constant defined by Equation 10
N = Motor speed, rpm
P = Load power requirement, hp
$q = at_1$
$r = at_2$
s = Slip in motor speed from synchronous at rated load, per cent
T = Load torque, lb-ft
T_M = Rated motor torque, lb-ft
${}_uT$ = Load torque per unit of rated motor torque
${}_uT_b$ = Per unit peak motor torque
${}_uT_M$ = Per unit of rated motor torque
t = Time interval in load cycle, seconds
WK^2 = Flywheel inertia, lb-ft^2

Subscripts: 1 and 2 denote specific time intervals or torque values; n denotes any time interval of torque value; S denotes synchronous

Basic Formulas

$$T_{avg} = \frac{t_1 T_1 + t_2 T_2}{t_1 + t_2} \quad (1)$$

$$T_{rms} = \sqrt{\frac{t_1 T_1^2 + t_2 T_2^2}{t_1 + t_2}} \quad (2)$$

$$P_{avg} = \frac{T_{avg} N}{5250} \quad (3)$$

$$P_{rms} = \frac{T_{rms} N}{5250} \quad (4)$$

$${}_uT_n = \frac{T_n}{T_M} \quad (5)$$

$$a = \frac{308\ T_M}{s\ N_S\ WK^2} \quad (6)$$

$$A = \frac{(1 - e^{-q})\ (1 - e^{-r})}{(q + r)\ (1 - e^{-(q+r)})} \quad (7)$$

$${}_uT_{M\,rms} = \sqrt{{}_uT_{rms}^2 - ({}_uT_1 - {}_uT_2)^2\ A} \quad (8)$$

$${}_uT_b = B + {}_uT_2 \quad (9)$$

$$B = \frac{({}_uT_1 - {}_uT_2)\ (1 - e^{-q})}{1 - e^{-(q+r)}} \quad (10)$$

$$WK^2 = \frac{308\ T_M}{a\ N_S\ s} \quad (11)$$

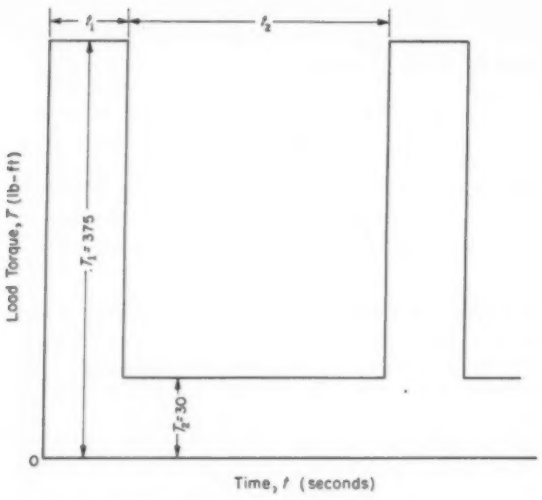


Fig. 4—Load cycle graph for the sample problem

Fig. 1 and the nomograms in *Figs.* 2 and 3, the load torques previously calculated must be given in terms of "per unit" values of rated motor torque. A per unit load torque ${}_uT$, is determined by simply evaluating the ratio of load torque over rated motor torque. Actually, if per unit load torque values were multiplied by 100, they would be in terms of per cent of rated motor torque.

For a 40-hp, 1750-rpm motor, rated motor torque is 120 lb-ft. Thus, from the general expression for ${}_uT$ in Equation 5, ${}_uT_1 = 375/120 = 3.12$ and ${}_uT_2 = 30/120 = 0.25$. Similarly, ${}_uT_{rms} = 170/120 = 1.42$.

The next step begins the trial-and-error process in which a value for the constant a is assumed. This constant is defined in Equation 6. Thus, for the motor assumed $a = 308\ (120)/0.5\ (1800)\ WK^2 = 410/WK^2$. A guess at a reasonable value for WK^2 might indicate a range somewhere between 0.2 and 4 for a. Try $a = 0.5$. Knowledge of the application combined with some experience with this solution method will permit the designer to pin down the value of a rather quickly.

With $a = 0.5$, the values of at_1, at_2 and $a\ (t_1 + t_2)$ are 1, 4 and 5, respectively. Apply these values in the *Fig.* 2 nomogram to find the value of the constant $A = 0.125$. This constant, which is defined in Equation 7, is used to verify the validity of the initial choice of $a = 0.5$ by substituting it in Equation 8, or

$${}_uT_{Mrms} = \sqrt{(1.42)^2 - (2.87)^2\,(0.125)} = 0.99$$

Since this value for motor loading is less than unity, it will be safe from a heating standpoint.

There is another important check which must be made, however, and that concerns the limits of motor torque obtained under the preceding conditions. If peak motor torque required per unit of rated motor torque is too great, the operation may exceed breakdown. This per unit peak motor torque value is obtained from Equation 9. The constant B is defined in Equation 10 and is easily evaluated by the nomogram in *Fig.* 3. In this example, B may be read from the chart as 1.83, and thus the per unit peak motor torque ${}_uT_b = 1.83 + 0.25 = 2.08$.

The value of ${}_uT_b$ should be on the linear part of the speed-torque curve in *Fig.* 1. Obviously the value of 2.08 is satisfactory if a NEMA Design D motor is chosen, but would *not* be satisfactory for a NEMA Design B motor because ${}_uT_b$ is in the region of breakdown. For a Design B motor, it would be necessary to try smaller values of a to reduce ${}_uT_b$ to an acceptable value.

Now that a satisfactory value of a has been obtained, the process of selecting flywheel inertia and motor slip is essentially complete. From Equation 11, which is Equation 6 rearranged, the value of WK^2 for a 5 per cent slip motor is $WK^2 = 308\ (120)\ /0.5(1800)\ (0.05) = 822$ lb - ft^2. For any other slip, the necessary flywheel inertia can be determined by the same relationship.

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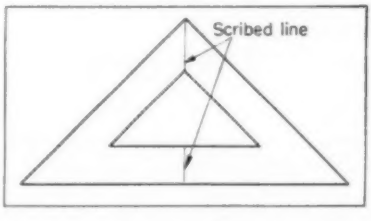
Tips and Techniques

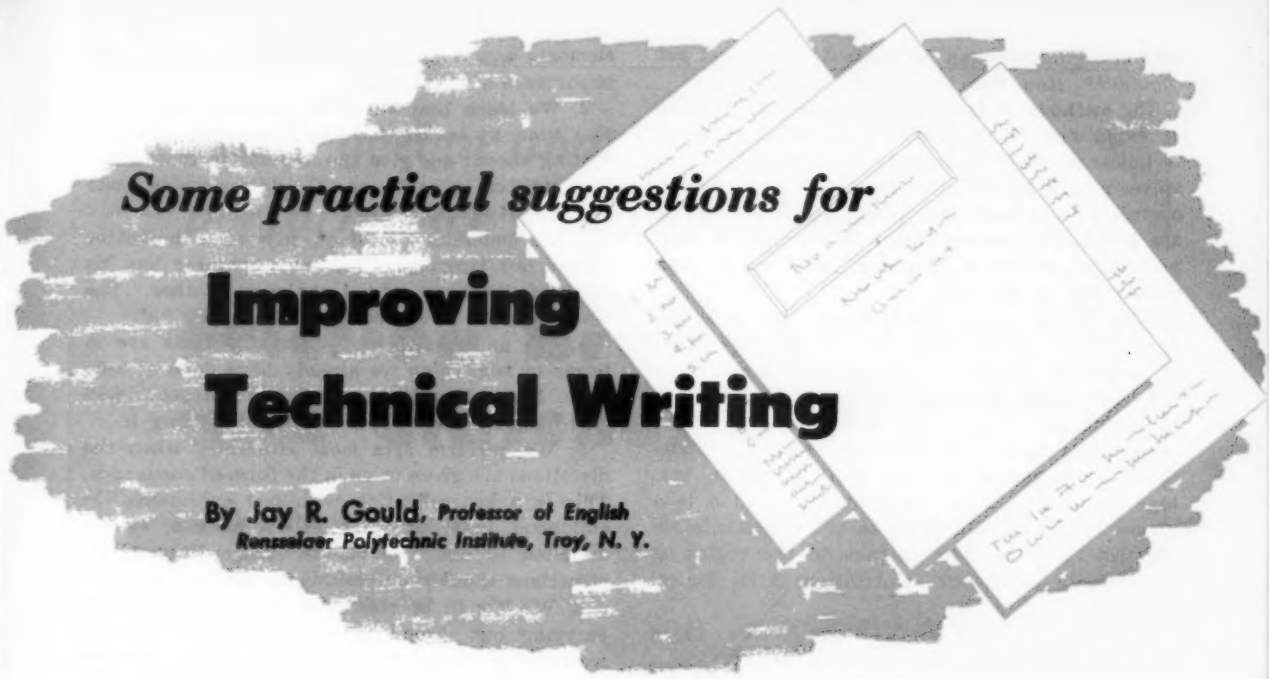
Drawing Perpendiculars

DRAWING perpendiculars to a line on a drawing that is not horizontal or vertical can be tricky. An easy and accurate method is to scribe a line



perpendicular to the long edge of a triangle. The long edge can then be placed accurately on the already-drawn line, and a point marked to locate the perpendicular.—RICHARD MARSH, *Lima, O.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.



Some practical suggestions for

Improving Technical Writing

By Jay R. Gould, *Professor of English*
Rensselaer Polytechnic Institute, Troy, N. Y.

TECHNICAL writing of any type will profit from the application of certain basic procedures. Preparation of an outline before the actual writing is begun provides a framework on which to build the writing and gives direction to it. Paragraphs should be constructed more or less according to a pattern. Writing will proceed more easily and will be more readable if a pattern is followed than if the writer is inconsistent in his methods.

The objective of most technical writing is to report, instruct or promote. Applying the methods of lucid writing will not only do the job of providing the reader with the information he needs, but will also utilize to the best advantage the limited writing time of the busy engineer.

Fundamentals of Definition: The very first thing the reader of a piece of technical writing wants to know is this: What is it—what's it all about? Whether the subject is the projection of a new company policy or the design of a piece of equipment, a natural question is: What is it?

Presenting a description of a product in a progress report or an instruction manual requires a basic definition to set a frame of reference for the device. Telling how a thing is built and how it works is secondary to telling what the thing is.

Solving the problem of definition may involve several of the following techniques: analyzing the object and telling something about its origin; giving the reader a quick idea of its end use; describing what it looks like; and describing a process using the object, or relating an incident in which the object played a large part.

No doubt some writers feel that analyzing the name of an object and giving its word origin is too elementary. But this is an age of telling the news not only to the expert, but also to the general public. The writer once heard a lucid description of *radar* which began with an explanation that the name comes from a combination of initials: *r* for radio, *d* for detection or direction finding; *a* for and; and *r* for ranging. This is an era of initial-naming, but to the new reader, words coined from initials may mean nothing.

The reader always should be given some means for determining what a thing looks like. Of course, pictures and diagrams will do this. But for some technical writing, especially in routine jobs requiring immediate attention, illustrating may not be possible. A specific, definite, down-to-earth vocabulary is necessary to indicate size, dimensions, and general shape. *Transistor* is a fairly long name for a small sized component. A description of its uses will not necessarily provide an idea of its appearance.

Another way of bringing an object or device to life is by relating an incident involving it. Recently the writer collaborated with a biologist on a popular treatment of bacteriophage, a species of virus. The principal method of vitalizing the article was to describe bacteriophage in terms of Louis Pasteur, Peter Koch, and other experimenters, in incidents involving them. Narrative writing was employed to provide interest and readability.

Technical Description: There are, of course, many ways of solving the problem of technical description. Every skilled writer has his own methods, whether he is preparing copy for a parts catalog or a detailed description of a new product. But how many writers go back to the very funda-

mental organizing plan: *What is it? How is it put together? How does it work?*

The methods of definition will solve the problem of explaining *What is it?* The second stage of technical description, *How is it put together?,* involves a trite but effective rule: A broad, general, overall picture should be presented before details are given. The reader cannot be expected to comprehend a subject if he doesn't first see it completely and in one piece.

"The circuit uses a 958-A Acorn tube in superregenerative receiver with 3Q4 receiver. By means of a unique switching system, the same tubes are used in the transmitter circuit." This was the beginning of a piece of writing which, three paragraphs later, described a "compact walkie-talkie contained in a 7 by 7-in. aluminum box, together with a 27-in. whip antenna and a telephone handset." Such an inverted presentation requires the reader to go back to the beginning and reread to get the information in its logical order.

How does it work? implies these factors: (1) a description of what happens when the device is put to work and its sequence of operation, (2) the theories and scientific principles behind the device, and (3) an indication of the personnel necessary to the functioning of the device.

Directive Writing: What is the best way to write directions to have them carried out most efficiently? Fundamentally, the laws of human behavior governing directive writing are:

1. We do our best work when we understand what we are to do, how much we are to do, and why we are to do it. In report writing, these elements would be called the purpose, scope, and importance of the work.

2. We learn best when we perform one action at a time, by taking one step at a time. Directive writing should not give the impression that it has been written in haste, nor should it inspire haste on the part of the reader.

3. We understand most quickly when the writer speaks our language. The sales engineer has his level of language, the technician another. The reader should always be kept in mind.

4. We understand best when directions are in terms of something we already have done or seen done. Instructional manuals should instruct as well as command, and this is one way of doing it.

5. We perform acts most efficiently when the directions are given to us in the form of commands. This is a generalization with few exceptions. In childhood, in school days, in our careers, we are adjusted to obey commands. The writer of instructions should not hesitate to give orders.

6. We like to be reassured, to feel that we are carrying out directions the right way and not wasting our time. But we can't always directly query the person who wrote the directions. The writer, then, should provide the reader with checkpoints to tell him that he is doing things in the right way, verbally and pictorially if possible.

7. We must be able to read directions easily. Manufacturers are often criticized for burying directions in a mass of description and explanation. Headings, italics, a variety of type faces and spacing should be employed to guide the reader. Comparatively short sentences and paragraphs should predominate, and writing style should be brief and crisp.

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industrial design Ideas

toss it out

ONE of the principal reasons for the huge success of ball-point pens is that they have retractable points. Elimination of the bother of removing and replacing a fountain pen cap proved to have irresistible appeal, and thus assured the success of this new product.

It's rather painful for me to discuss this subject at all, because if I had followed through on my clean scoop of this idea, I'd now be well on the way to my third million.

It seems that years ago I got fed up with the everlasting putting-on and taking-off of the cap covering the eraser of my mechanical pencil. Then one day, inspiration struck—I tossed the cap into the waste basket and was thenceforth a happier and wiser man. And that, basically, is just what some smart pen designer did; he eliminated the nuisance factor!

Now, whenever I use a mechanical pencil or ball-point pen, I am subconsciously put on the alert for the nuisance factors that frequently creep into machine designs.

Although much thought has been put into product efficiency, a careful review of your designs, with this specific point in mind, may reveal to you many small details that can be further refined or, better yet, *eliminated!*

—Cliff

Basic design and performance considerations for

Friction Brakes and Clutches

By Howard B. Huntress
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Friction surfaces in contact are subject to certain operating forces and effects that must be controlled in a friction mechanism. In this article, basic factors influencing the design and performance of friction clutches and brakes are considered.

Other related articles on the general subject of friction and its effects have dealt with friction fundamentals (July 1955), sintered-metal friction materials (November 1955) and multiple-disk clutches and brakes (March 8, 1956).

DESIGN and operation of friction clutches and brakes are based on the forces developed by surfaces in direct contact. Methods of controlling these friction forces take different forms in practice, but practically all employ one of two basic surface constructions: disk or drum. Cone clutches and other similar devices, although sometimes considered as a separate type, represent a combination of the drum and disk principles.

In friction devices of the disk type, engagement force is applied axially to compress the disk elements. Torque developed is a function of the size and number of disks, the coefficient of friction at the contact surfaces, and the force of engagement, *Fig.* 1 (symbols are defined in *Nomenclature*). Design and performance characteristics of the multiple-disk units were treated in detail in a previous article. (MACHINE DESIGN, March 8, 1956).

With the drum construction, engagement forces are radial. Industrial drum clutches and brakes are either internal-expanding or external-contracting types, according to whether friction surfaces move radially outward or inward to engage the drum. Certain designs utilize multiple blocks with an expanding tube which applies the pressure to engage the blocks against the drum, *Fig.* 2. The internal expanding-tube construction, which has been effectively employed in aircraft brake applications, is capable of exerting high torque and absorbing large amounts of energy.

Torque developed by the drum mechanism is a function of drum radius, pressure of surface engagement, effective area of contact surface, and coefficient of friction. These relationships for an

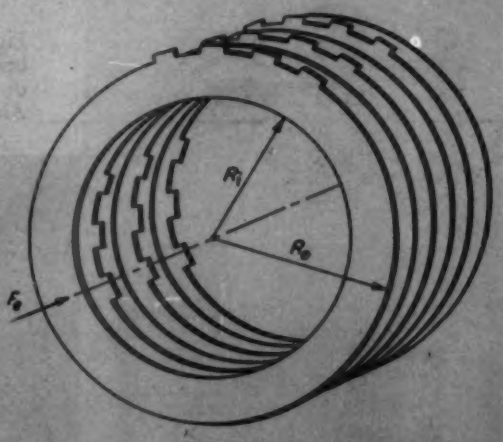


Fig. 1 — Basic design and torque relationships for multiple-disk friction mechanism

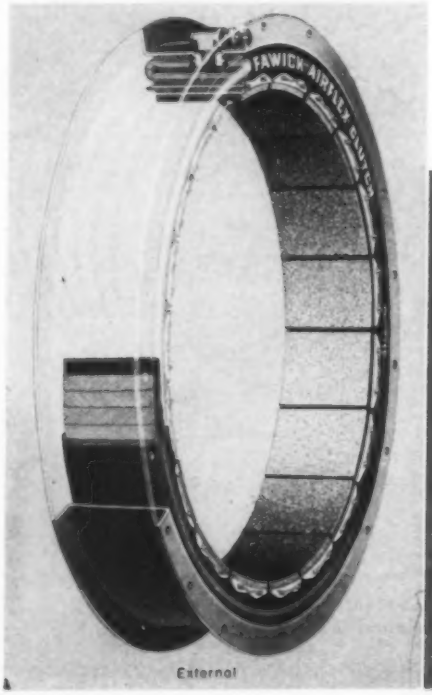
expander-tube drum construction are shown in *Fig.* 3.

Features of both the drum and disk mechanisms have been combined in the cone type unit. Engagement force is usually applied axially and is multiplied at the contact surfaces by a factor dependent on the cone angle. Torque developed by the cone mechanism is a function of the inner and outer radii of the friction surface, the cone angle, the force of engagement, and the coefficient of friction at the contact surfaces, *Fig.* 4. As cone angle θ approaches 0, the torque developed, τ, approaches infinity. At $\theta = 0$, the cone becomes a drum. When $\theta = 90$ deg, the cone becomes a single-faced disk.

One of the chief objections to the cone clutch arises from difficulties of disengagement which develop after operation from exposure to dust and dirt. Score marks and ridges on the drum and lining surfaces may impede sliding. Although increasing the cone angle would apparently improve the ability to release, it would also lower the mechanical

Nomenclature

A = Effective area of friction contact surfaces, sq in.
A_s = Exposed surface area of brake, sq ft
a = Acceleration, ft per sec per sec
B = Weight of heat absorbing material of brake, lb
E = Kinetic energy of a moving body, ft-lb
E_h = Energy converted to heat during braking, ft-lb
F = Force applied to a body, lb
F_e = Axial force of engagement in cone and disk mechanisms, lb
g = Acceleration due to gravity, 32.2 ft per sec per sec
H = Rate of heat loss by radiation, Btu per sec
n = Number of double-faced friction disks
P = Power, hp
P_i = Instantaneous power developed by brake, hp
p = Contact pressure at friction surfaces, psi
Q = Rate of conversion of kinetic energy to heat, Btu per sec
q = Specific heat of brake material, Btu per lb per deg F
R = Radius of friction surface of brake drum, in.
R_i, R_o = Inside and outside radii, respectively, of friction surfaces on cone and disk mechanisms, in.
R_w = Effective radius of wheel, in.
S = Distance traveled, ft
T = Temperature, deg Rankine
t = Elapsed time, sec
t_T = Total elapsed time, sec
v = Instantaneous velocity, mph
W = Weight of moving body or wheel load, lb
V = Initial velocity, mph
ΔT = Temperature rise, deg F
θ = Cone angle (*Fig.* 4), deg
μ = Coefficient of friction
τ = Torque developed by brake or clutch, lb-in.
ϕ = Power density of a brake, hp per sq in.



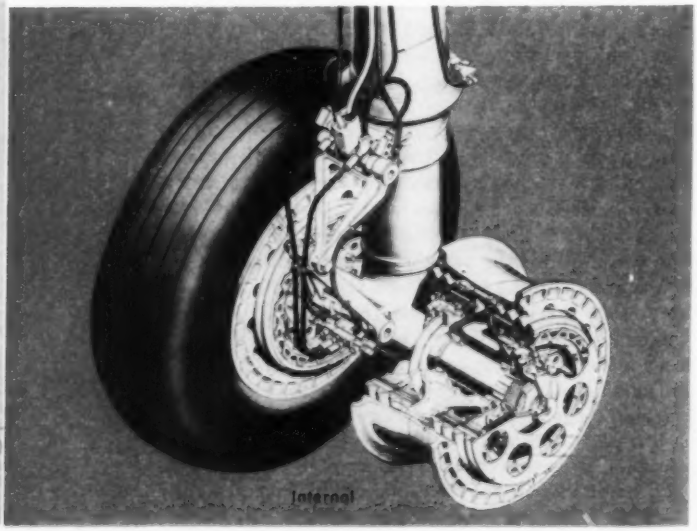


Fig. 2 — Typical internal and external expander-tube brake designs in which engagement is pneumatically or hydraulically actuated. Photos, courtesy (left) Fawick Airflex Div., Fawick Corp. and (right) B. F. Goodrich Co.

advantage of the clutch assembly.

An important advantage of the cone mechanism lies in the ability to concentrate force at a large diameter while providing sufficient friction-surface width for durability. A full 360 deg of lining material is available. Moreover, no expanding mechanism is required, engagement pressure is light, "wrap-up" in the mechanism is eliminated, and full operating effectiveness can be maintained with little adjustment. Cone clutches are usually mechanically operated by means of a manual lever.

All of the mechanisms discussed are suitable for application as brakes or clutches. Brake service is frequently the most demanding from the standpoint of design requirements and will be given primary attention here. However, many of the same considerations apply equally to clutch design and application.

Performance characteristics of the different brake types are subject to certain design controls and limitations. The multiple-disk mechanism gains torque capacity through the addition of disks or through increase of the ID of the friction surfaces. The first approach acts also to increase durability but the latter reduces it. For the drum brake, increasing the width of the friction surface increases durability but does not necessarily provide a corresponding gain in torque capacity. The cone mechanism gains in torque capacity as the cone angle decreases. This angle reduction acts to increase the allowable width of the friction surface as well as the effective diameter.

Fundamental Braking Relationships: A moving vehicle, because of its mass and velocity, has kinetic energy. To change the velocity of a moving vehicle, a force must be applied to the mass, resulting in an acceleration or deceleration according to the direction of force application:

$$a = \frac{Fg}{W} \quad \ldots\ldots (1)$$

Retarding forces on moving vehicles usually take the form of traction forces between the wheel and the ground, *Fig.* 5,

$$F = \frac{\tau}{R_w} \quad \ldots\ldots (2)$$

Combining Equations 1 and 2 gives the expression for torque required to impart a deceleration to a vehicle,

$$\tau = \frac{Wa\,R_w}{g} \quad \ldots\ldots (3)$$

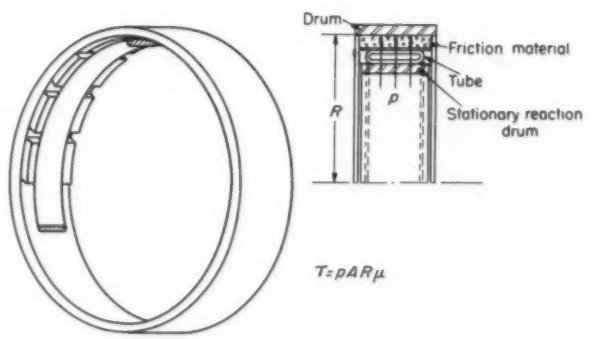
This "vehicle" torque expression can be related to the brake torque expression by the friction coefficient μ. For the expander-tube brake, *Fig.* 3,

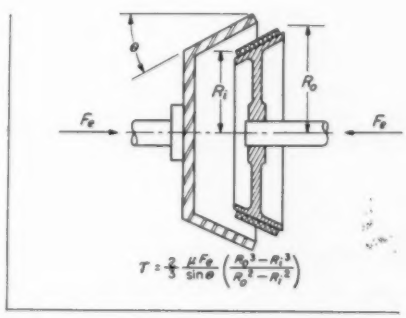
$$\tau = \frac{Wa\,R_w}{g} = pAR\mu \quad \ldots\ldots (4)$$

and

$$\mu = \frac{Wa\,R_w}{pAgR} \quad \ldots\ldots (5)$$

Quantity W/pA is the ratio of the wheel load to the applied braking force. The ratio of acceler-





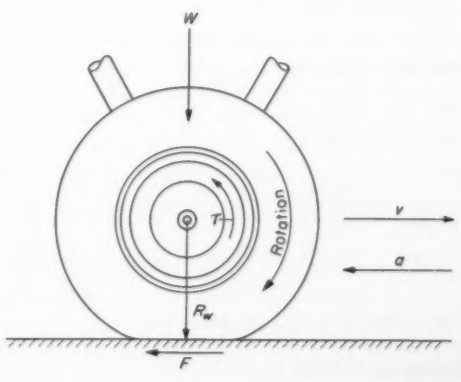


Fig. 3—Above—Basic design and torque relationships for expander-tube type drum mechanism

Fig. 4—Above, right—Basic design and torque relationships for the cone type friction mechanism

Fig. 5—Right—Analysis of forces acting on wheel during braking

ations, a/g, is sometimes referred to as the ground coefficient, while R_w/R is the mechanical advantage of the wheel over the brake.

Kinetic energy of a moving vehicle is given by

$$E = \frac{WV^2}{2g}\left(\frac{88}{60}\right)^2 = 0.0334\ WV^2 \quad \ldots\ldots\ldots\ldots (6)$$

The load on a brake is usually judged by the power at initial application, a quantity called the "initial energy rate" (IER). At the moment the brakes of a moving vehicle are applied, they begin to convert kinetic energy to heat at a rate which is initially high, but which decreases with speed until both speed and power are zero. The instantaneous power developed by a brake is

$$P_i = \frac{Wav}{550g}\frac{88}{60} = 8.29(10^{-3})Wav \quad \ldots\ldots\ldots\ldots (7)$$

where W represents the wheel loading or the inertia equivalent and a becomes deceleration.

The IER, which is the power at the initial velocity V, can be found from Equation 7 by substitution of the appropriate velocity value.

The ability of the brake to carry the power burden placed upon it depends upon the area of the brake surfaces. The ratio of these two quantities is called the power density. Thus, the initial power density of a brake is

$$\phi = \frac{P_i}{A} = 8.29(10^{-3})\frac{WaV}{A} \quad \ldots\ldots\ldots\ldots (8)$$

In braking a great mass from high velocity to a stop, it is generally desirable to decelerate at a constant rate. To achieve constant deceleration, constant torque must be applied. It will perhaps be helpful to analyze completely the stopping action and its effect on the different performance variables.

If the coefficient of friction remains constant, then constant pressure of engagement produces constant torque, and constant deceleration.

The velocity at any instant is given by

$$v = V - \frac{60}{88}at \quad \ldots\ldots\ldots\ldots (9)$$

Total time for the stop is,

$$t_T = \frac{88}{60}\frac{V}{a} \quad \ldots\ldots\ldots\ldots (10)$$

Distance traveled during time interval t by a decelerating vehicle is

$$S = \frac{88}{60}Vt - \frac{1}{2}at^2 \quad \ldots\ldots\ldots\ldots (11)$$

The kinetic energy at $t = 0$ is $E_0 = 0.0334\ WV^2$. The kinetic energy remaining at velocity v is $E_1 = 0.0334\ Wv^2$.

The kinetic energy converted to heat at velocity v is

$$E_h = E_0 - E_1 = 0.0334\ W(V^2 - v^2) \quad \ldots\ldots\ldots\ldots (12)$$

Combining Equations 9 and 12,

$$E_h = Wat\ (0.04555\ V - 0.01554\ at) \quad \ldots\ldots\ldots\ldots (13)$$

The energy converted to heat is made manifest as an increase in the temperature of the friction elements. The temperature rise resulting from the conversion of kinetic energy to heat during braking is

$$\Delta T = \frac{E_h}{778\ Bq} \quad \ldots\ldots\ldots\ldots (14)$$

Since the brake material is usually mainly steel, or material of similar specific heat, q may be assumed to be 0.112 Btu per lb per deg F. From Equations 13 and 14 then,

$$\Delta T = \frac{Wat}{B}10^{-4}\ (5.23V - 1.784\ at) \quad \ldots\ldots\ldots\ldots (15)$$

A typical example of a vehicle braking stop is provided by an airplane at landing. Performance data are: Plane weight, 88,000 lb; number of wheels, 4; number of brakes, 8; loading per brake, 11,000 lb; landing velocity, 100 mph; deceleration, 10 ft per sec per sec; weight of brake, 40 lb.

Computed values for the characteristics of the braking action at successive time intervals from the beginning of the stop are given in *Table* 1. Curve plots of these data are shown in *Fig.* 6.

Maximum Drum Temperature: Since the function of a brake is to convert kinetic energy into heat, it is necessary to know what the temperature of the mechanism will be during and after a stop. This characteristic depends on the weight of heat-absorbing material in the drums and lining, and the specific heat of the material.

Although some heat will be lost through radiation, conduction and convection, computation will show that even the radiation loss at maximum drum temperature will be slight in comparison to the friction heat input. Conduction losses will be negligible because there is not much metal in contact with the drum. Moreover, convection losses are minimized because brake drums are placed within the wheel and there is little direct air flow against the heated surfaces. However, the chief reason why heat losses are low during braking is that most of the braking action will have been completed and velocity will be low before the temperature of the drum becomes high enough to make the rate of heat loss by the foregoing methods appreciable.

In determining the maximum temperature which a brake will attain, it is on the safe side to assume that no heat will be lost. The temperature rise ΔT can then be calculated from Equation 14 if it is further assumed that all the heat is evenly distributed over the entire brake assembly, that there is no change in phase (such as melting) to cause heat absorption at constant temperature, and that all the materials have the same specific heat.

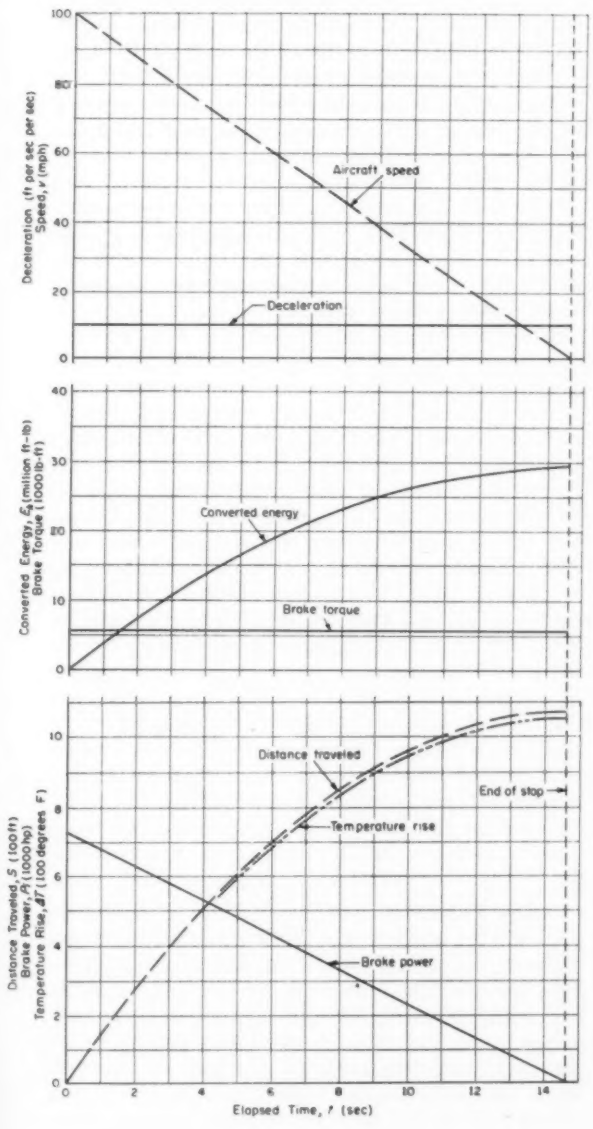
Radiation Heat Loss: The rate of heat loss by radiation is small in comparison to the rate of heat conversion by the brake. This condition can be shown by studying the two corresponding rate expressions.

The rate of heat loss by radiation for a brake is

Table 1—Typical Performance Data for Aircraft Brake

Elapsed Time t (sec)	Aircraft Speed v (mph)	Brake Power P_i (hp)	Distance Traveled S (ft)	Converted Energy E_h (million ft-lb)	Temperature Rise ΔT (deg F)
0	100	7300	0	0	0
1	93	6800	141.5	3.87	140
2	86	6280	273	7.46	269
3	80	5800	395	10.8	387
4	73	5280	506	13.8	495
6	59	4300	700	19.1	685
8	46	3320	852	23.3	835
10	33	2390	965	26.4	946
12	18	1310	1040	28.4	1020
14.65	0	0	1070	29.4	1054

Fig. 6 — Typical performance curves for aircraft brake. Plots are based on data in *Table* 1



$$H = 0.386\ (10^{-12})\ A_s\ (T_2^4 - T_1^4) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (16)$$

where T_2 is the temperature of the exposed brake surface and T_1 is the temperature of the surroundings. The value of the constant in this expression, 0.386 (10^{-12}), is based on an emissivity coefficient of 0.8 and a Stephan-Boltzmann constant of radiation of 0.174 (10^{-8}) Btu per hr per sq ft per deg Rankine to the fourth power. If T_2 is appreciably above the ambient temperature, the effect of T_1 is small, and the quantity, T_1^4, in Equation 16 can be ignored in calculations.

The rate of conversion of kinetic energy to heat in a brake can be found from

$$Q = 5.86\ (10^{-5})\ Wav \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (17)$$

Setting Equation 16 equal to Equation 17 and solving for v gives an expression for the velocity at which the rate of conversion of kinetic energy to heat equals the rate of heat loss by radiation:

$$v = 0.659\ (10^{-8})\ \frac{A_s T_2^4}{Wa} \quad \ldots\ldots\ldots\ldots\ldots\ (18)$$

Use of this equation requires some knowledge of the temperature limitations of the drum. Thus, if the maximum allowable operating temperature of the drum during a stop is known and the brake dimensions are given, the speed at which the maximum temperature will occur, based on radiation heat losses, can be found. At the same time, of course, the equation is also useful in evaluating the effects of the other design variables and may be generally helpful as a qualitative guide for brake analysis.

As an example, assume the following data is known for an expander-tube brake on an airplane: Friction surface diameter, 20 in.; friction surface width, 4½ in.; maximum operating temperature, 1000 F; wheel load per brake, about 11,000 lb; and deceleration, 10 ft per sec per sec. From Equation 18, using these data, the speed at which the heat generated is equal to the heat dissipated by radiation will be found to be only about ½-mph. If heat loss were only from radiation, then the temperature would continue to rise practically to the end of the stop.

Surface Temperature: Another important consideration in brake performance that has received a great deal of attention is the temperature of the friction surfaces. The actual surface temperature appears to be a very elusive value, and is difficult to evaluate, particularly under extreme braking conditions.

One of the most common methods of measuring the temperature of a lining or drum uses a fine thermocouple mounted in a small hole drilled as close to the friction surface as possible. While this method involves a small lag factor, it no doubt measures fairly accurately the temperature of the body of the material at the position of the junction of the thermocouple. Successive measurements closer to the surface indicate that the temperature

increases sharply toward the surface. Extrapolation of these data yields surface temperatures which are quite high.

An interesting analysis of temperature characteristics of metal surfaces in contact is presented by Bowden and Tabor.* Temperatures were measured by utilizing the two surfaces at the hot junction in a thermocouple. Bowden shows that the maximum temperature reached by any part of the surfaces of two metals in frictional contact is the melting temperature of the lower melting material. The area of the high temperature spots was found to be small, in the order of 0.0001-sq in. Also, duration of the high temperature bursts was short, in the order of 0.0001-sec.

Bowden found that if the rate of conversion of energy is low, there will be only a few high-temperature spots in a given space and time. As the rate of energy conversion increases, however, the frequency of the high-temperature bursts, as well as the temperature of each burst, increases.

The important point brought out, however, is that no matter how much the rate of energy conversion is increased, the maximum temperature of the bursts does not exceed the melting temperature of the lower melting material. (Melting temperature of the metallic friction material used was less than that of the drum material.)

These observations lead to a better understanding of the mechanism of conversion of kinetic energy to heat. It can be assumed that if the energy of the application is large, a great portion of the surface will be at the melting temperature for a part of the time. Each high-temperature burst of energy involves only a small area and a thin skin of the friction material. It may be assumed that a small thin area of the drum adjacent to this spot is also involved. The energy is converted to heat in this small volume of metal, and both the drum and the friction material absorb the heat. The temperature of this minute volume is the melting temperature of the metallic lining. However, the temperature of the adjacent volumes of the lining, or drum, is considerably lower, and is the temperature which would be computed by extrapolation of the instantaneous measurements of temperature along the thickness of the friction material. Therefore, the heat at the high-temperature point will be conducted rapidly away from the surface, with the action being further assisted by the fact that the volume of metal increases as the distance from the point of origin increases.

It can be seen from the previous discussion, then, that there are actually two temperatures existing at the contact surface at the same time. One is the general, overall temperature of the lining at the surface, corresponding to the extrapolation of the temperature gradient in the lining, and the other is the melting temperature of the lining. The higher temperature exists almost instantaneously over small areas. When the energy rate increases, the frequency of the temperature bursts will increase, but the maximum temperature will not increase. On the other hand, the overall surface temperature of the lining will increase as the rate of energy conversion goes up. Using a glass drum and operating the friction mechanism in the dark, Bowden has shown rather conclusively that the heat is released in bursts. The high-temperature bursts appeared as bright flashes of light, increasing in frequency as the rate of energy conversion increased.

Heat-Flow Characteristics: The flow of heat away from the contact surfaces depends on the thermal conductivity of the friction material. Lack of conductivity is advantageous in certain applications, such as aircraft brakes, as a means of preventing conduction of heat to the interior of the brake unit. There is the disadvantage, however, that heat generated at the interface of the two friction surfaces can be dissipated in one direction only and therefore the drum must receive all the heat of a stop. This condition has the effect of increasing the running temperature of a brake.

From the broad viewpoint, there are several ways of reducing the severity of the heat problems: (1) Increase the weight of heat-absorbing material, (2) utilize materials of high heat capacity, and (3) provide a means for cooling the elements during the stop so that heat which results from the energy conversion will not only be stored in the drum, but will also be carried away by one of the usual means of heat transmission. In brakes whose temperature rise is rather low, the heat dissipation provided by radiation is rather small. Although the rate of heat loss by radiation increases as the fourth power of the absolute temperature, it still does not become appreciable at road vehicle temperatures. Conduction, which is one of the most powerful methods of heat transmission, is limited in a brake because the nature of the design limits the path through which the heat may move and also because, outside of the drum itself, there is not a great deal of metal into which the heat may go. Another powerful method of heat transmission is forced convection which is made possible by the air stream moving past the drum when the vehicle is in motion. The fact that drums are so small and tires so big, having the effect of hiding the drum in the tire, militates against increasing heat loss by this method. Where cooling is a critical factor, the cooling effect of convection on the drum can be increased by the addition of fins, or scoops, which tend to increase the flow of air into the drum.

Drum Expansion: Among the major differences between the multiple-disk friction mechanism where pressure is applied axially and the drum type friction mechanism where pressure is applied radially from the inside is the reaction to temperature. When a pack of friction disks and mating plates in a multiple-disk brake is engaged in a severe stop, the temperature of the whole pack may rise to 1000 F. Under these conditions the disk diameter will expand. For a 14-inch steel disk, for ex-

*F. P. Bowden and D. Tabor—*The Friction and Lubrication of Solids*, Oxford at the Clarendon Press, England, 1950, Page 33.

ample, the diameter expansion at this temperature will be about 0.098-in. An estimate of the expansion of the same pack in an axial direction, from a "cold" thickness of about 2.3 inches, shows the change in thickness to be considerably less: 0.016-in. This expansion operates against the applied pressure; that is, the change in dimensions tends to close up the operating clearances in the pressure application system.

Now, if this were a drum brake of 14 in. diameter, and the temperature of drum were raised to 1000 F in a stop, the expansion of the brake drum would be the same as for the outside diameter of the disk pack: 0.098-in. In contrast to the effect on the multiple-disk brake, however, the expansion is in a direction away from the pressure, since pressure in the internal-expanding brake is applied from the inside out. Therefore, to continue the pressure on the drum, which is receding from the center of pressure, the hydraulic pressure system must have sufficient capacity to follow up the expansion of the drum.

A further requirement on the hydraulic system, whether it is for the multiple-disk or for the drum type brake, is that it have sufficient capacity to follow up wear on the friction faces. However, this requirement is mollified by the fact that brake adjustments can usually be made to reset the linings close to the drum, or to take up the clearance in a multiple-disk brake. If the expansion of a drum type brake is greater than the follow-up capacity of the hydraulic system, temporary loss of braking power will result.

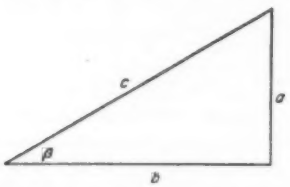
High-Temperature Effect: Friction materials may be destroyed by the very temperature they create. The brake is in truth an engine in which kinetic energy is converted to heat energy, with an efficiency of conversion of 100 per cent. Like other converters, the brake must be composed of suitable materials to allow the continual use of the "engine" within the scope of its capabilities. The friction pair, however, has several functions. Not only must it have the correct friction properties to cause the conversion to heat, but it must have the physical properties to resist the heat once developed without melting, deforming or oxidizing. Moreover, it must have the mechanical properties to withstand the pressures and speeds necessary to its function. Many of the answers to these problems are being provided by present friction materials. At the same time, new developments continue to extend the range of application possibilities to meet the demands of increased speeds and loads in design.

Tips and Techniques

Integral-Number Right Triangles

TRIANGLES with integral-number sides, such as the familiar 3-4-5 triangles, can be useful in layout and design work if some latitude in locations is possible. Thus, a hole can be located at an integral-number distance from any location, with both co-ordinates and radial distance expressed as integral numbers.

The table shows integral-number right triangles in which two or three of the numbers are below



200. The tabulation is arranged in order of the tangent of the smaller angle in the triangle.

Multipliers can obviously be used on all sides to change the numerical values in any ratio desired; original integral numbers can then be used for layout of angles, etc.—HENRY HALLE, *Chicago Midway Laboratories, Chicago.*

tan β	β	a	b	c
.064 5833	3° 41′ 43″	31	480	481
.069 0476	3° 57′ 00″	29	420	421
.074 1758	4° 14′ 32″	27	364	365
.080 1282	4° 34′ 52″	25	312	313
.087 1212	4° 58′ 45″	23	264	265
.091 0973	5° 12′ 18″	44	483	485
.095 4545	5° 27′ 09″	21	220	221
.100 251	5° 43′ 29″	40	399	401
.105 556	6° 01′ 32″	19	180	181
.111 455	6° 21′ 35″	36	323	325
.118 056	6° 43′ 59″	17	144	145
.125 490	7° 09′ 10″	32	255	257
.133 929	7° 37′ 41″	15	112	113
.143 590	8° 10′ 16″	28	195	197
.154 762	8° 47′ 51″	13	84	85
.167 832	9° 31′ 38″	24	143	145
.183 333	10° 23′ 20″	11	60	61
.202 020	11° 25′ 16″	20	99	101
.225 000	12° 40′ 49″	9	40	41
.253 968	14° 15′ 00″	16	63	65
.291 667	16° 15′ 37″	7	24	25
.315 152	17° 29′ 32″	52	165	173
.323 864	17° 56′ 43″	57	176	185
.342 857	18° 55′ 29″	12	35	37
.364 286	20° 00′ 57″	51	140	149
.376 068	20° 36′ 35″	44	117	125
.416 667	22° 37′ 12″	5	12	13
.449 198	24° 11′ 22″	84	187	205
.467 532	25° 03′ 27″	36	77	85
.487 500	25° 59′ 21″	39	80	89
.504 808	26° 47′ 06″	105	208	233
.533 333	28° 04′ 21″	8	15	17
.565 476	29° 29′ 14″	95	168	193
.589 286	30° 30′ 37″	33	56	65
.622 222	31° 53′ 27″	28	45	53
.643 939	32° 46′ 45″	85	132	157
.659 341	33° 23′ 55″	60	91	109
.679 739	34° 12′ 20″	104	153	185
.750 000	36° 52′ 12″	3	4	5
.818 713	39° 18′ 28″	140	171	221
.838 095	39° 57′ 58″	88	105	137
.852 564	40° 26′ 59″	133	156	205
.872 727	41° 06′ 44″	48	55	73
.902 778	42° 04′ 30″	65	72	97
.952 381	43° 36′ 10″	20	21	29
.991 667	44° 45′ 37″	119	120	169

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Fig. 1

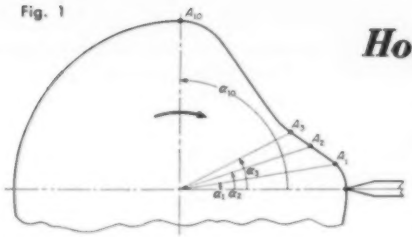
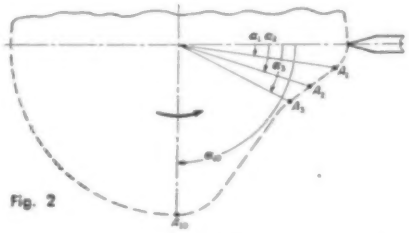


Fig. 2



How direction of rotation affects

CAM PROFILES

By Sigmund Rappaport
Ford Instrument Co.
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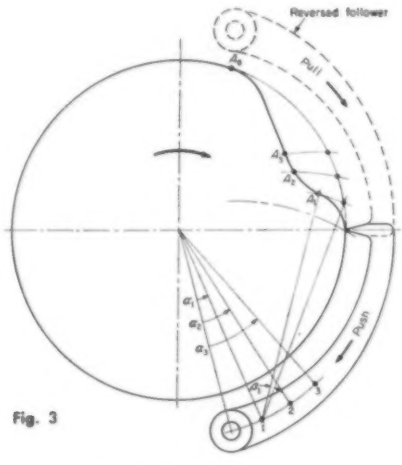
Long Island City, N. Y.

AN unsymmetrical cam rotating in the "wrong" direction—that is, opposite to the design direction—obviously produces the wrong follower motion. In design, the problem of reversed cam rotation may occur, for example, in the layout of right-hand and left-hand versions of a particular mechanism. A question arises in such cases: If the clockwise cam is "flopped over" on its shaft, will it provide the correct follower motion when rotating in the counterclockwise direction? The answer depends on the type of follower.

Radial Followers: A cam and knife-edge radial follower are shown in *Fig.* 1. The discussion applies equally to a roller follower. Assuming that the desired follower motion is specified, the cam has the profile in *Fig.* 1 when designed for clockwise rotation. If counterclockwise rotation is intended, the cam profile is that shown in *Fig.* 2.

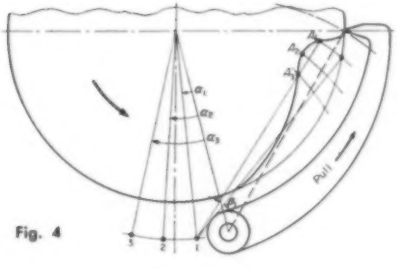
It is quite apparent that these two profiles are mirror images of each other. When flopped over on its shaft, the clockwise cam may be used on a counterclockwise shaft.

Fig. 3



Oscillating Followers: As in the preceding example, the desired follower motion has been specified. Assuming a clockwise design direction for the cam, the profile in *Fig.* 3 results with an oscillating follower. If counterclockwise rotation is intended, the cam profile is that shown in *Fig.* 4.

Fig. 4

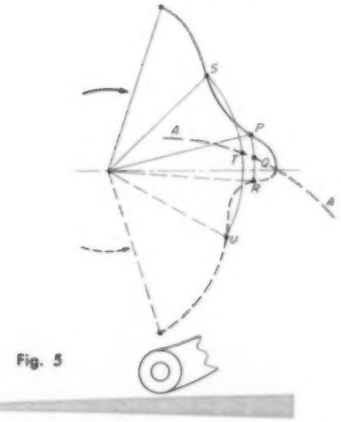


These cam profiles are neither identical nor mirror symmetrical. As illustrated in *Fig.* 5, the profiles have a special kind of symmetry with respect to the arc *AA* traced by the follower point. Here, arc *PQ* is shown to equal arc *QR*, *ST* equals *TU*, and so on.

For the cam driving an oscillating follower, distortion of follower motion due to reversed rotation is not corrected when the cam is flopped over. Where follower velocity and acceleration are of paramount importance, or in applications requiring the transmission of a given mathematical function, the cam must be redesigned if rotational direction is reversed.

The effect of reversed cam rotation is, of course, equivalent to reversed follower arm location (*Fig.* 3). Sense of cam rotation can, in fact, be conveniently expressed in terms of frictional push or pull on the follower arm. In this system of reference, clockwise rotation corresponds to arm "pull"; counterclockwise rotation corresponds to arm "push."

Fig. 5



MACHINE DESIGN
Data Sheet

A basic outline of

Physical Mechanics

- **Displacement, velocity, and acceleration**
- **Force and mass**
- **Equilibrium**
- **Work and energy**
- **Moments**

By George H. Logan
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PHYSICAL mechanics is a big subject. Fortunately the band of topics applied most frequently in design engineering is narrow. Despite the explosive progress of science and engineering over the last decade, these fundamentals have a stability that only enhances their importance. They are the tools that get the most use. This article provides an easy-to-use outline of those principles of physical mechanics that arise most often in design.

Displacement and Velocity

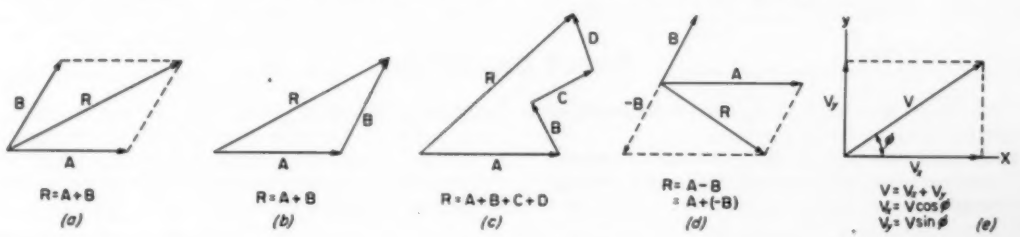
Displacement and velocity are typical *vector* quantities. They have both magnitude and direction. Other examples are acceleration, force, and momentum. *Scalar* quantities have magnitude only. Examples are speed, mass, and volume. In this article, vector quantities are denoted by boldface type—for example, displacement **A**. Scalar magnitudes of vectors and all other scalar quantities are shown in italic. In this notation, *A* is the scalar magnitude of vector **A**.

Displacement occurs as translation and/or rotation. A moving body has *translation* when every straight line in the body remains parallel to its original position. A moving body has *rotation* when all points in the body travel in circles about the axis of rotation. Any complex motion can be resolved into translation and rotation.

Addition of displacements creates a *resultant* displacement. Addition of displacements **A** and **B** by the *parallelogram* method is shown in *a*. An identical resultant is given by the *triangle* method, *b*. The addition of three or more vectors is conveniently carried out by the *polygon* method, *c*.

Subtraction of displacements also creates a vector resultant. In *d*, **B** is subtracted from **A**. This is done by reversing the sign of **B** (that is, reversing its direction) and adding vectorially to **A**. The resultant is **R**.

Velocity is the rate of change of displacement. When velocity is constant, $V = s/t$. A point has variable velocity when displacements vary in magnitude, in direction, or both, for equal increments of time. Such a point has an instantaneous velocity given by the derivative of displacement with respect to time: $V = ds/dt$. Because velocity is a vector quantity, it can be resolved into components along any chosen axis as shown in *e*. The vector sum of the components equals the resultant velocity.



DATA SHEET

Acceleration

Acceleration is the time rate at which velocity changes. For a point moving in a straight line, useful relations between velocity, v, acceleration, a, and displacement, s, written in scalar notation, are

$$a = \frac{v - v_0}{t}$$

$$v = v_0 + \left(\frac{v - v_0}{t}\right) t$$

$$v_{avg} = \frac{v + v_0}{2}$$

$$s = v_{avg}\, t$$

$$= \left(\frac{v + v_0}{2}\right) t$$

$$s = v_0\, t + \frac{a\, t^2}{2}$$

$$v^2 = v_0^2 + 2as$$

For the special case of a freely falling body, $a = g$ = acceleration of gravity = 32.2 ft per sec^2. Air friction will diminish acceleration of a falling body to a lower value, but air friction is usually negligible.

When acceleration is not a constant, that is, when acceleration is varying in magnitude or direction or both, instantaneous acceleration is given by $a = dv/dt$.

In a, consider a point that moves with constant speed of magnitude v in a circle. Note that the point velocity is not constant since the point is continuously changing direction.

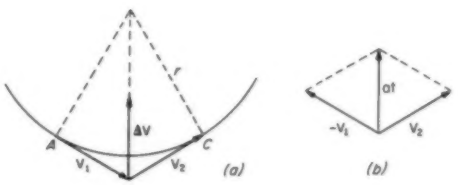
As the point moves from A to C, its velocity changes (in direction) from $\mathbf{v}_1$ to $\mathbf{v}_2$. The change in velocity $\Delta\mathbf{v} = \mathbf{at}$ (see b) is given by

$$\mathbf{at} = \mathbf{v}_2 - \mathbf{v}_1$$
$$= \mathbf{v}_2 + (-\mathbf{v}_1)$$

Acceleration is directed toward the center of the circle and has a magnitude

$$a = \frac{v^2}{r}$$

A point may have several different, concurrent, accelerations. These vector quantities can



be vectorially combined into a single resultant acceleration. Moreover, a resultant acceleration can be resolved into components along chosen axes.

Rotation

A *radian* is an angle subtending an arc of length r. Thus 2π radians = 360 deg.

When the initial angular velocity of a body is ω_0 radians per unit time, and the angular acceleration is a constant radians per unit time^2, then the angular velocity ω at the end of an interval t will be

$$\omega = \omega_0 + \alpha\, t$$

The average angular velocity during the interval is

$$\omega_{avg} = \frac{\omega + \omega_0}{2}$$

The angular displacement in radians for the interval is

$$\phi = \omega_{avg}\, t = \left(\frac{\omega_0 + at + \omega_0}{2}\right) t$$

$$\phi = \omega_0\, t + \frac{1}{2}\alpha\, t^2$$

Eliminating t between the foregoing expressions for ω and ϕ,

$$\omega^2 = \omega_0^2 + 2\,\alpha\,\phi$$

Tangential acceleration a and angular acceleration α are related as follows:

$$v_0 = \omega_0\, r$$

where v_0 and ω_0 are tangential and angular velocities at the beginning of interval t. Then

$$v_0 + at = r(\omega_0 + \alpha\, t)$$

at the end of interval t. From these two equations

$$\alpha = \frac{a}{r}$$

Force and Mass

Newton's laws of motion provide the foundation for *force* and *mass* concepts:

1. A body maintains a state of rest or uniform motion unless acted upon by a force to change that state.
2. An unbalanced force acting on a body accelerates the body in the direction of the force, and the acceleration is directly proportional to the force and inversely proportional to the mass of the body.

Force and Mass (cont.)

3. Action and reaction are equal in magnitude and opposite in direction.

Force produces *acceleration*. The property of a body that causes it to resist being accelerated, that is, causes it to persist in a state of rest or uniform motion, is *inertia*. The mass of a body is a measure of its inertia. *Momentum* is the product of mass and velocity.

According to the second law, if an unbalanced force F acting on a body gives it an acceleration a, any other force acting on the same body imparts a different acceleration a_1, or

$$\frac{F}{F_1} = \frac{ma}{ma_1}$$

For a freely falling body, the unbalanced force acting is body weight w; the acceleration is that due to gravity, $g = 32.2$ ft per sec^2 (or 386 in. per sec^2). Replacing F_1 by w and a_1 by g

$$\frac{F}{w} = \frac{a}{g}$$

and

$$F = \frac{w}{g}a = ma$$

In the foot-pound-second system both weight w and force F are expressed in pounds.

The product of a force and the time interval of its action is *impulse*, or $Ft = mat$.

But at is the velocity change caused by the force. Thus *impulse* of a force equals the momentum change produced by the force.

$$Ft = m(\Delta v) = m(v - v_0)$$

Below, body A_1 moves in a circle. The body has acceleration toward the center, $a = v^2/r$. Thus body A_2 must exert a force on A_1 to cause

this acceleration, and the force exerted is $F = mv^2/r$. But by Newton's third law, A_1 must exert an equal and opposite force on A_2. This force, directed outward along the radius, is called *centrifugal force*. It has the value

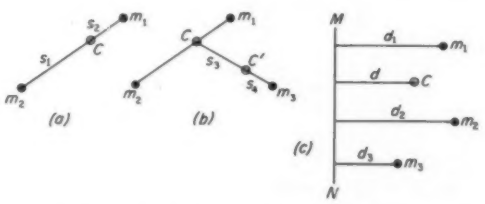
$$F = \frac{mv^2}{r}$$

Force is a vector quantity. The resultant of two or more forces acting on a body is the single force which will produce the resultant acceleration. The resultant force can be obtained by the vector resolution technique previously described. When the resultant force is zero, the body is in equilibrium and the forces do not change the state of rest or motion of the body.

Center of Mass

A rigid body may have concurrent combined motions of translation and rotation. There is one point in such a body, however, that has only translational movement. This point is called the *center of mass*. In *a*, C is the center of mass of particles m_1 and m_2. Location of the mass center is defined by: $S_1/S_2 = m_2/m_1$

Let a third particle, m_3, be added to the system as in *b*. Then, C will be the mass center



for all three particles as determined by $S_4/S_3 = (m_1 + m_2)/m_3$

In *c*, line MN is the intersection of a plane perpendicular to the page. Location of the center of mass C of the system of particles m_1, m_2, m_3, . . ., m_n is found by taking moments about MN, or

$$d = \frac{m_1d_1 + m_2d_2 + m_3d_3 + \ldots + m_n d_n}{m_1 + m_2 + m_3 + \ldots + m_n}$$

It can also be shown that

$$(m_1 + m_2 + m_3 + \ldots + m_n)v = m_1 v_1 + m_2 v_2 + m_3 v_3 + \ldots + m_n v_n$$

and

$$(m_1 + m_2 + m_3 + \ldots + m_n)a = m_1 a_1 + m_2 a_2 + m_3 a_3 + \ldots + m_n a_n$$

Where v and a are the velocity and acceleration of the center of mass.

The center of mass moves as if all of the forces acting on the body were transferred, with their directions unchanged, to the center of mass. Except for problems in celestial mechanics, the *center of gravity* can be taken as identical with the center of mass.

Resultant of Forces

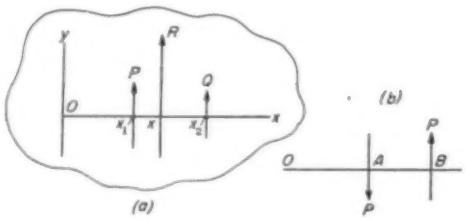
When a number of forces act on a body, they are equivalent in effect to a single force called a *resultant*. When the several forces are replaced by their resultant, the linear acceleration of the mass center remains unchanged; and the angular acceleration about the mass center

Resultant of Forces (cont.)

remains unchanged. Hence:

1. The resultant must have components in the x, y, z directions equal to the sum of the separate force components in those directions.
2. The resultant must have moments about the x, y, z axes through the center of mass equal to the sum of the separate force moments about those axes.

In *a*, forces P and Q in the plane of the page act at x_1 and x_2 respectively. The mass center of the body is at O. Assume that the z axis



passes through O, perpendicular to the page.

A single force $R = P + Q$ satisfies the first condition since its component in any direction equals the sum of the components of P and Q in that direction.

The point of application of R satisfying the second condition is found by summing moments about the z axis, or

$$Rx = Px_1 + Qx_2$$

$$x = \frac{1}{R}(Px_1 + Qx_2)$$

Thus the moment of R about the z axis equals the sum of the moments of P and Q about the same axis.

In this example P and Q each have zero component moments about either x or y axes. Thus R has zero component moment about these axes.

Two equal and opposite forces not colinear form a *couple*, *b*.

A couple has no resultant. The sum of the moments of the two forces is the same about all axes perpendicular to the plane of the couple, and is equal to $P(AB)$. The distance AB is the *arm* of the couple.

A couple produces no linear acceleration of the mass center. The angular acceleration produced by a couple is about an axis through the mass center.

Equilibrium of Forces

When the forces acting on a body are in equilibrium, the forces cause no linear or angular acceleration. That is, their resultant is zero. Thus, the sum of the force components in the x, y, z directions is zero, and the sum of the moment components about the x, y, z axes is zero. The x, y, z axes can be placed anywhere. These equilibrium relationships are expressed by

$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma F_z = 0$$

$$\Sigma T_x = 0 \qquad \Sigma T_y = 0 \qquad \Sigma T_z = 0$$

Certain cases of equilibrium are of interest:

1. When two forces are in equilibrium, they must be equal in magnitude, opposite in direction, and colinear.
2. When three forces are in equilibrium, they must all exist in one plane.
3. Three forces in equilibrium must either be parallel or must pass through a single point.

Work and Energy

Work is defined as the product of the force F acting on a body by the distance the body moves in the direction of the force, or

$$W = Fs$$

The time rate at which work is performed is *power*, or

$$P = \frac{W}{t} = \frac{Fs}{t}$$

When the force varies, work done can be computed either by graphical summation or by analytical integration. Both methods are illustrated in the sketch.

$$W = \sum_{s_0}^{s_x} F(\Delta s)$$

$$= \int_{s_0}^{s_x} F ds$$

For integration, F must be expressed as a function of s, that is, $F = (f)s$.

The *kinetic energy* of a body is defined as

$$E_k = \frac{1}{2} mv^2$$

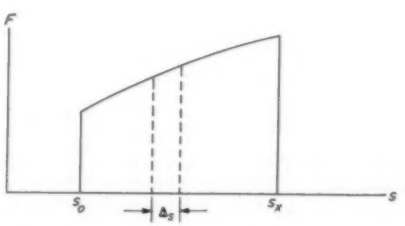
The work done on a body equals the kinetic energy gained by the body. This is shown by

$$v^2 = v_0^2 + 2as$$

$$= v_0^2 + \frac{2Fs}{m}$$

$$Fs = \frac{1}{2} mv^2 - \frac{1}{2} mv_0^2$$

Potential energy is the capacity a body has for doing work because of its position. A body at height H has potential energy



Work and Energy (cont.)

$$E_p = mgH$$

If a body at height H falls freely to a lesser height h, its loss in potential energy equals its gain in *kinetic energy*, or

$$mgH - mgh = \frac{1}{2} mv^2 - \frac{1}{2} mv_0^2$$

Thus the sum of potential energy and kinetic energy possessed by a body is constant, since, by transposition,

$$mgH + \frac{1}{2} mv_0^2 = mgh + \frac{1}{2} mv^2$$

In these discussions, friction has been assumed zero. However, energy must be expended to overcome friction, and this energy is converted to heat.

Moment of Forces

In *a*, a particle of mass m is free to rotate about C.

The effectiveness of F in angularly accelerating m is proportional to both r and F. The measure of this effectiveness is called *moment of force*, or *torque*, defined as

$$T = Fr = (mr\alpha)r = mr^2\alpha$$
$$= I\alpha$$

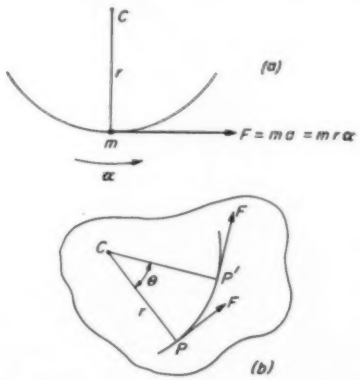
The quantity mr^2 is called *moment of inertia*, I, and is the measure of the resistance of the particle to angular acceleration. For example, flywheels are constructed with mass concentrations at the outer rim to create a high value for I and thus resist speed variations.

If a body is made of many particles, m_1, m_2, m_3, . . ., m_n, then:

$$F_1 r_1 + F_2 r_2 + F_3 r_3 + \ldots + F_n r_n$$
$$= (m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \ldots + m_n r_n^2)\alpha$$

$$T = \sum_{r_1}^{r_n} mr^2 \alpha = I\alpha$$

Without change in the I of a body, all of the mass can be considered to be concentrated at a



radius K from the axis of rotation. Radius K is defined as the *radius of gyration*. Then

$$I = MK^2$$

From the expression for T, we can write $Tt = Iat$. But at equals the change in angular velocity over the time t. Thus

$$Tt = I(\omega - \omega_0)$$

Term $I\omega$ is *angular momentum*. Hence the rate of change of angular momentum is $I\alpha$, for ω is changing at rate α. Thus *moment of force* is equal to the rate of change of angular momentum. By the *conservation of momentum* principle for rotation, total angular momentum of a body system remains constant if there are no external forces to cause acceleration.

At *a*, the linear velocity of m is ωr. Therefore the kinetic energy of the particle is

$$E_k = \frac{1}{2} m(\omega r^2)$$

For a body composed of many particles,

$$E_k = \frac{1}{2}\omega^2 \sum_{r_1}^{r_n} mr^2$$

$$= \frac{1}{2} I\omega^2$$

Total kinetic energy of a body is the sum of the kinetic energy due to translation of the mass center and the kinetic energy due to rotation about the mass center.

When a moment of force rotates a body through an angle, work is done. In *b*, force F acting at radius r rotates a body through angle θ about an axis through C.

From *b*,

$$T = Fr$$

$$PP' = r\theta$$

$$W = F(PP') = Fr\theta$$

$$= T\theta$$

If rotation of the body is not resisted, T will produce angular acceleration α, of magnitude $\alpha = T/I$. Let the angular velocity at the beginning and the end of the displacement be ω_0 and ω, respectively. From the previous expression,

$$\omega^2 = \omega_0^2 + \frac{2T\theta}{I}$$

$$T\theta = \frac{1}{2} I\omega^2 - \frac{1}{2} I\omega_0^2$$

Thus the work done by the moment of force is equal to the increase of kinetic energy produced by the moment of force.

DESIGN ABSTRACTS

Power transmission characteristics of

Hydraulic Torque Converters

By P. L. Fosburg

Elevator Div.
Westinghouse Electric Corp.
New York

A HYDRAULIC torque converter serves as a variable torque amplifier. It also may be described as an automatic compensator for changes in output torque demand.

Basically, the torque converter is a variable-speed transmission which simplifies gearing requirements but generally does not eliminate them. Due to its variable-speed characteristic, it sometimes creates new applications by replacing other forms of drive such as dc motor controls, and where such applications can be made it is found that an overall simplification of equipment results.

It is finding increasing use on both on-highway and off-highway vehicles. Machines such as front-end loaders, scrapers, bulldozers and other equipment with variable loading conditions make ideal applications. It is used also to great advantage on industrial applications such as mixers, blenders, shovels and oil-well servicing equipment. Here again, these applications require handling of variable-output loads.

A torque converter has several advantages when used in conjunction with an adequate multispeed gear reduction:

1. It permits the engine to be operated at all times at its most efficient speed.
2. It prevents the engine from lugging or stalling at lower output speeds.
3. It minimizes the skill required of the operator in handling the vehicle or other device.
4. It provides a smooth application of power which in a vehicle, for instance, will prevent spinning of the wheels with resultant tire wear and loss of traction.
5. It provides a more efficient work cycle and results in more work done per horsepower and per hour.

A hydraulic torque converter is a hydrokinetic device. It is one of two related devices frequently used in transmissions. One is the hydraulic coupling and the other the converter. The torque converter, *Fig.* 1, can be compared to the ac-

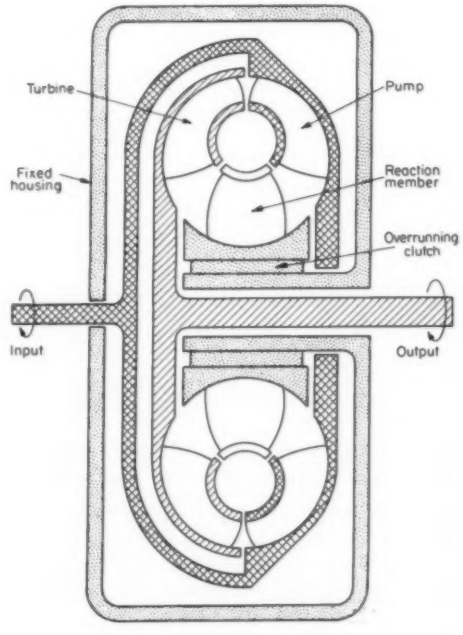


Fig. 1—Schematic of a hydraulic torque converter

tion of a motor-generator set and dc motor in that output speed and output torque can be controlled in the same fashion as in an electrical system. There are several different kinds of converters in use. The most common form is the single-stage converter, although two and three-stage units also are in service. Greater torque multiplication can be obtained by incorporating additional stages. The amount of torque multiplication which can be obtained varies between two and six depending upon the type of design. Generally, a single-stage unit will give a maximum multiplication somewhere between 3 and 3.5. Some used in automobiles give as low as 2.0.

The single-stage converter consists of three basic elements: the pump, turbine, and reaction member. The centrifugal pump converts the mechanical energy of the driving engine or motor into kinetic energy in the fluid being circulated. This fluid then enters the turbine wheel and gives up its energy in the form of torque and rotation. As the fluid leaves the turbine, it enters the reaction member where the direction of flow is reversed so that the oil, with its unexpended energy, enters the pump in the same direction as its rotation. If this reaction member were not present, the direction of fluid emerging from the turbine would oppose the action of the pump and would prevent the multiplication of torque.

At the stall condition, when the output member is stationary, the energy in the fluid impinging upon the turbine is converted into torque. As the turbine starts to move, this torque decreases until such time as the turbine approaches the same rotational speed as the pump wheel. As the speed of both pump and turbine approach synchronization, the torque multiplication decreases to unity and we then have the equivalent of a fluid clutch or flywheel. When this occurs, the reaction member is permitted to free-wheel in order to get it out of the way of the fluid flow, allowing the fluid to pass unimpeded through the hydraulic circuit.

The basic apparent differences between a torque converter and a

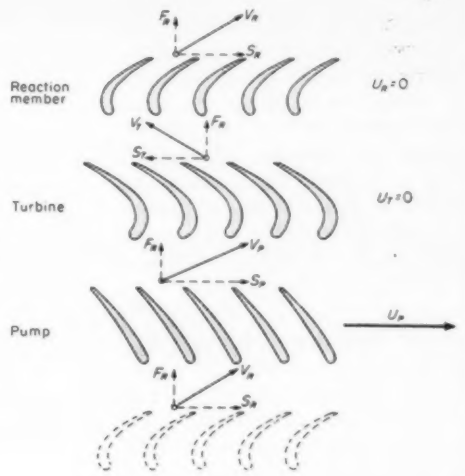


Fig. 2—Stall condition in a hydraulic torque converter showing relative velocity U of each member and velocity V of oil

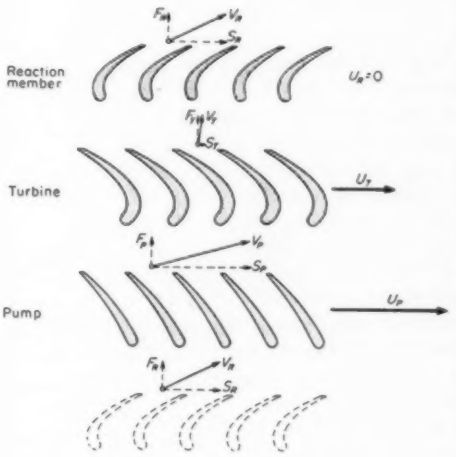


Fig. 3—Condition at 0.5 speed ratio

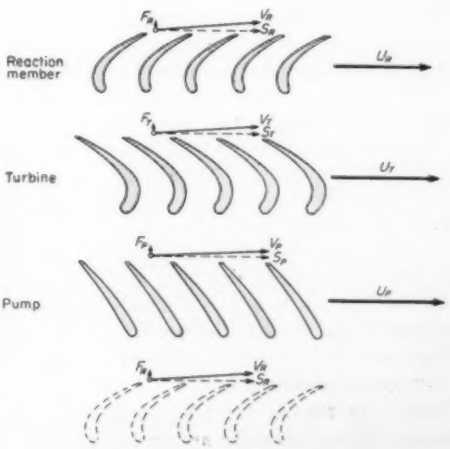


Fig. 4—Relative velocities of converter components at coupling speed

hydraulic coupling are that the blades in both pump and turbine are curved in the torque converter. This results in the turbine absorbing energy in stopping the spinning flywheel of fluid and also reversing the direction of the flywheel as it leaves the turbine. As a result of this reversal of spin, it is necessary to add a third member or stator to redirect the flow of oil back to the pump.

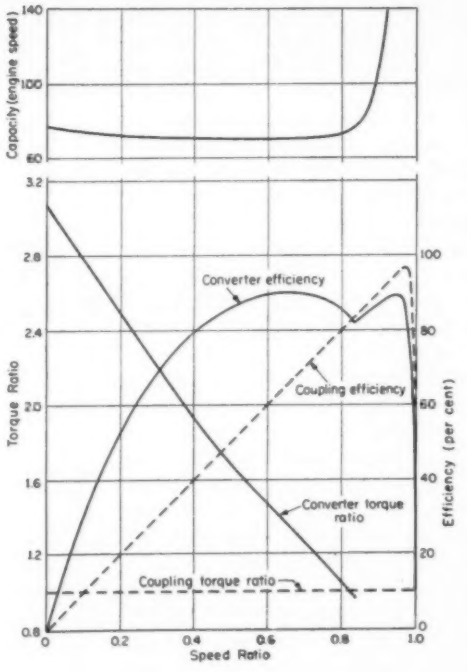


Fig. 5 — Operating characteristics of a typical hydraulic torque converter compared with a hydraulic coupling

Stall Condition: In observing the action of the oil as it passes through the elements of the converter under various conditions of operation, first consider the stall condition where the pump is rotating at engine speed and the output member or turbine is stationary. This is a condition which would occur when starting under full load.

In *Fig.* 2, the blades of the three members are shown and the relative velocity of each member is indicated by the length of the arrow *U*. In the stall condition, only the pump is rotating. Both turbine and stator are fixed. Oil enters the pump along the vector line V_r. The horizontal component S_r is in the direction of rotation of the pump. The vertical vector F_r represents the torus flow or flow of the oil through the hydraulic circuit.

As the oil passes through the pump, it accelerates and acquires kinetic energy. As it leaves the pump, its velocity vector is such that it impinges upon the turbine blades with a minimum amount of turbulence and in such a fashion as to transfer the desired amount of torque. As the oil passes through the turbine, the flow of oil is reversed since the turbine blades are stationary. Thus, the turbine has not only stopped the flow of oil coming from the pump but has actually reversed its direction. In other words, the fluid flywheel which entered the turbine spinning in one direction leaves the turbine as a fluid flywheel spinning in the opposite direction.

Thus, the reason for the third member in the system is apparent, since the oil emerging from the turbine is traveling in a direction opposite to that of the rotation of the pump, and if this fluid were permitted to enter directly into the pump, it would be necessary for the pump to first supply enough energy to reverse the direction of flow before accelerating the oil to return it to the turbine. This obviously would result in loss of considerable torque and power; however, with the fixed stator in place, the direction of oil is changed so that it returns to the pump in the pump's direction of flow.

This action results in multiplication of torque. Maximum flow of oil through the circuit occurs under this stall condition. The magnitude of the vector *F* is an indication of the amount of torque multiplication in the system. The magnitude of the work going on inside the converter can be visualized when it is known that in a converter capable of transmitting 250 hp, flow of oil through the circuit at stall condition amounts to a transfer of 80 gallons per second.

Half Speed: A second condition to consider is when the turbine has partly come up to engine speed. *Fig.* 3 shows the condition at 0.5 speed ratio which indicates that the turbine is rotating at half the speed of the pump. Here again, the stator is still stationary. Velocity of the oil entering the pump is in the same general direction as in the case of the stall condition, but this velocity is not quite as great. Similarly, the flow through the circuit denoted by the vector *F* is less since the rotation of the turbine has resulted in a counter-centrifugal force tending to resist the flow of oil through the system.

The flow of oil leaves the pump in a direction to drive the turbine wheel, but the exit velocity of the oil due to rotation of the turbine has altered the direction of flow to the stator so that it is almost directly in line with the entrance angle of the stator blades. In this condition, only the top half of the stator blades are effective in diverting the flow of oil in a direction for re-entry into the pump. The oil flow through the torus is reduced from that which occurred in *Fig.* 2.

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Coupling Range: The condition existing at the clutch point is illustrated in *Fig.* 4. This condition occurs when the load has been brought up to speed and, for all practical purposes, output speed is the same as input speed. Actually, output velocity must always lag input if torque is to be transmitted. The condition shown here is the equivalent of that obtained in a hydraulic coupling. Oil enters the pump in a direction almost tangential to the rotation of the pump and leaves the pump along the same line, but with some velocity added to it. Since the turbine is going at approximately the same speed as the pump, oil leaves the turbine along a very similar vector.

If the stator were to remain fixed under this condition, the blades would offer a severe obstruction to the passage of oil, which would result in considerable turbulence and power loss. Therefore, the stator is permitted to free wheel as the oil strikes it in order to get the blades out of the way of the oil flow so that the fluid may be returned to the pump with minimum disturbance or change in direction. This free wheeling of the stator provides a condition similar to that of a hydraulic coupling. Circulation of oil is very small compared with the previous condition.

Operating Characteristics: Operating characteristics of a typical hydraulic coupling and torque converter are shown in *Fig.* 5. Dotted lines represent the characteristics of the hydraulic coupling while solid lines show the characteristics of the converter. Efficiency of the coupling is proportional to the speed ratio or inversely proportional to the amount of slip. Throughout its operating range, the torque ratio remains constant at unity. Thus, if the coupling is operated with a speed ratio of 0.3 which is equivalent to a slip of 70 per cent, the efficiency is 30 per cent.

The torque converter has a rising efficiency curve which reaches its maximum at a speed ratio of about 70 per cent and then drops off until it reaches the clutch point, where the converter begins to act as a coupling and then starts to rise along a line approaching that of the hydraulic coupling. Both the coupling and the converter fall off to zero efficiency as input and output approach synchronism. The area between the efficency line for the coupling and for the converter represents the increase in operating efficiency of the converter over that of the coupling. At 0.3 speed ratio the torque converter has an efficiency of approximately 70 per cent as compared to 30 per cent for the coupling. The output torque is greatest at the stall speed which in the example shown, is approximately three times the torque of the input. This torque ratio drops off until it reaches unity at the clutch point. These curves show that the greater the load and the greater the tendency for the engine to be slowed down, the greater the torque available at the load in order to perform the driving function.

The upper curve is a measurement of the capacity of the converter and is also an indication of engine speed driving the converter. It indicates that the driving engine can be operated at essentially constant speed which permits the engine to be operated at its most efficient rating. The sudden rise in speed of the engine beyond the clutch point indicates that the torque transmission capability of the converter as it reaches synchronism is decreasing and, as a result, is unloading the engine, permitting it to increase its speed. It is customary to govern the engine to prevent it from running away.

The flat capacity curve characteristic is a common one for industrial applications. The same curve for a converter used in a passenger automobile would have a sharply rising characteristic rather than a flat one, in order to overcome the sense of racing the engine when starting the automobile from standstill.

The torque converter provides a variable-speed transmission over a range of approximately three to one which, in effect, is an automatic transmission, self-adjustable to load conditions imposed upon it. This characteristic would be sat-

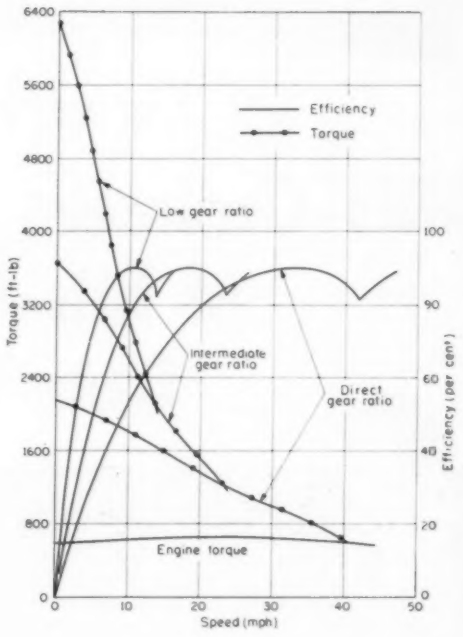

Fig. 6 — Torque and efficiency curves for a three-speed transmission used in conjunction with a hydraulic torque converter

Facing Page—ITEM 618→

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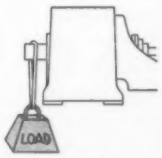

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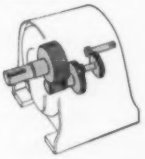

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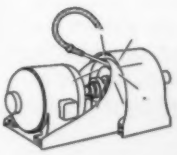

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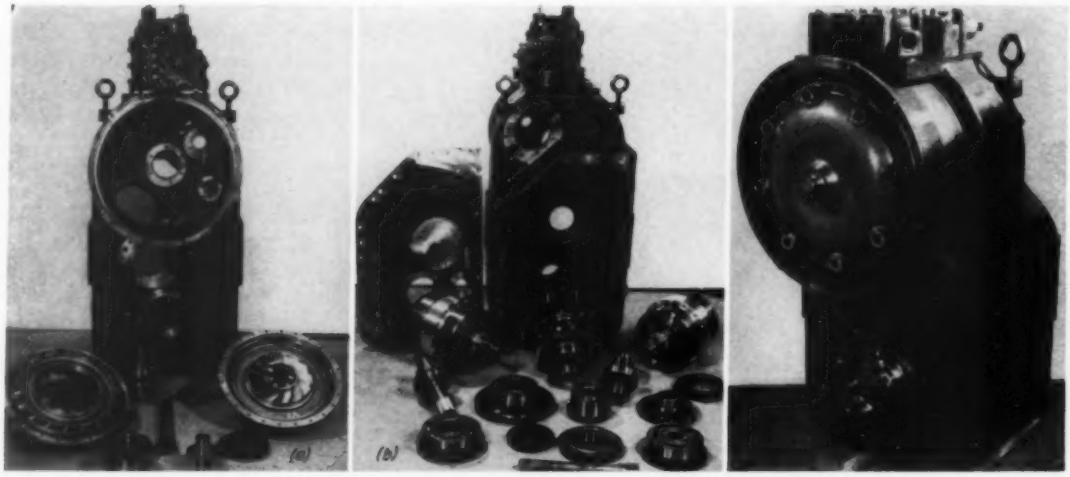

Fig. 7—A transmision unit employing gears in conjunction with a hydraulic torque converter showing the converter end with converter parts exposed, *a;* the gear end with transmission gearing and clutch assemblies exposed, *b;* and a completely assembled unit, *c*

isfactory for certain fixed conditions where this range of torque multiplication would be adequate to fulfill the performance requirements; however, if operation of the equipment requires a wide speed range or a wide range of output torque, performance would not be satisfactory.

Additional Gearing: In order to overcome this difficulty, it is necessary that different gear ratios be provided to shift the efficiency curve across the speed range so that the engine-transmission combination works at an acceptable efficiency level and torque multiplication level at all times. To accomplish this, a transmission with several gear ratios must be provided. *Fig.* 6 illustrates what happens when a three-speed transmission is used in conjunction with a converter installed in a vehicle. The low and intermediate gear ratios effectively shift the efficiency to the lower ground speeds so that, in effect, it is possible to obtain maximum efficiency for almost the entire speed range of the vehicle. For example, at 10 mph, instead of an efficiency of approximately 50 per cent, the efficiency when using low gear is 90 per cent. Additional torque is also provided at the same time, as a result of the increased gear reduction. A transmission unit employing gears in conjunction with a hydraulic torque converter is shown in *Fig.* 7.

Both the hydraulic coupling and the torque converter are inherently shock isolators between engine and load. As a result, sudden impacts or shocks appearing at the work are not transmitted back to the prime mover, nor are vibrations of any great magnitude transmitted through the transmission system. Therefore, it is possible to design a drive based on a smooth flow of power rather than based on severe impact loads. Design safety factors may be reduced as much as 75 per cent when using a fluid drive instead of a straight mechanical drive. This permits the designer to design his equipment more for running loads than for starting or shock loads. This, of course, results in reduced material costs and weight.

Applications: Torque converters, because of their characteristics, make it very easy to parallel two or more prime movers. They tend to balance out the load automatically since one unit cannot pull the other as would be the case in a direct mechanical drive. If, for instance, two or more drives were used on a conveyor belt, each would produce its proportionate share of the load without the need for any synchronizing device to tie them together. If for any reason, one of the units had to be removed for servicing, it would still be possible to operate the system at reduced speed with the remaining units, since each unit would contribute a greater torque under the load condition and permit operation to continue.

The torque converter provides high starting torque and is especially suited for applications where there is a high inertia load to start or where there is high break-away friction.

One example of what can be accomplished through the use of a torque converter can be described by a case that involved a blending machine. This particular application required the machine to have

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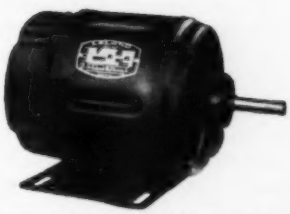


Illustrated is a Leland fractional hp, 115/ 230 v ac drip-proof, ball-bearing, repulsion-start induction-run motor.

Another AMF Product

LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY

—ITEM 619—

For More Information Circle Item Number on Yellow Card—page 19

a rather high starting torque to get the mixer in motion. As originally designed, this required a 40-hp electric motor. Measurements of horsepower requirements on the actual installation showed that the running horsepower was only 13½ hp. A fluid coupling between the driving motor and the machine was tried, and it was found that the motor size could be reduced from 40 to 30 hp. Having made this start, it was decided to see what could be done by putting a torque converter on in place of the fluid coupling. When the torque converter was installed, it was found that the driving motor could be reduced again from 30 to 15 hp. Reduction in size of the motor as well as reduction in size of the gear transmission made the cost of the installation less than the cost of the original equipment. The main savings, however, showed up in the reduced power consumption of the unit.

Torque converters can be applied to advantage wherever:

1. There is a requirement for high starting torque and low running torque.
2. There is a penalty on design because of shock loading.
3. There is a variable load condition (particularly in conjunction with internal combustion engines).
4. There is a need to improve operating performance and work efficiency without requiring an increase in operator's skill.

From a paper entitled "The Torque Converter in Power Transmissions" presented at the Semi-Annual Meeting of AGMA in Chicago, October 1955.

How Surface Finish Affects Titanium Alloys

By G. M. Sinclair, H. T. Corten and T. J. Dolan

Dept. of Theoretical and Applied Mechanics
University of Illinois
Urbana, Ill.

THE method employed in surface finishing influences fatigue strength of metal members. Recent evidence indicates that this influence is exaggerated in the case of titanium alloys to an extent not found in other structural metals.

The effect of various surface-finishing operations on the fatigue strength of RC 130B and Ti 140A titanium alloys has been investigated. Such operations as rough machining, surface cold-rolling, and grinding introduce different degrees and different depths of cold work and residual stress in the surface layers of the metal which strongly influence its resistance to fatigue. Indentation hardness readings of the surface layer reflect the degree of cold work and to a lesser extent the residual stress present. A correlation was found between indentation hardness of the test surface and its fatigue strength. Roughness of the surface also influences fatigue strength but the effect does not appear to be as important as that of hardness.

Within the limits of experimental evidence, the following conclusions appear to be justified:

1. Machining and finishing operations produce a disturbed metal layer on the surface of RC 130B and Ti 140A titanium alloys which strongly influences fatigue strength.

2. Indentation hardness surveys indicate that the disturbed metal layer may extend 0.012 to 0.015-inch below the surface in the case of simple machining while grinding may produce a surface "softer" than the original material.

3. As a first approximation, the relationship between fatigue limit, roughness and surface hardness may be expressed as:

$$Z = 207\, X^{-0.0284}\, Y^{1.017}$$

where Z = fatigue limit, psi; X = rms surface roughness, micro-inches; and Y = Knoop surface hardness (100-gram load).

This equation may be interpreted as indicating the following:

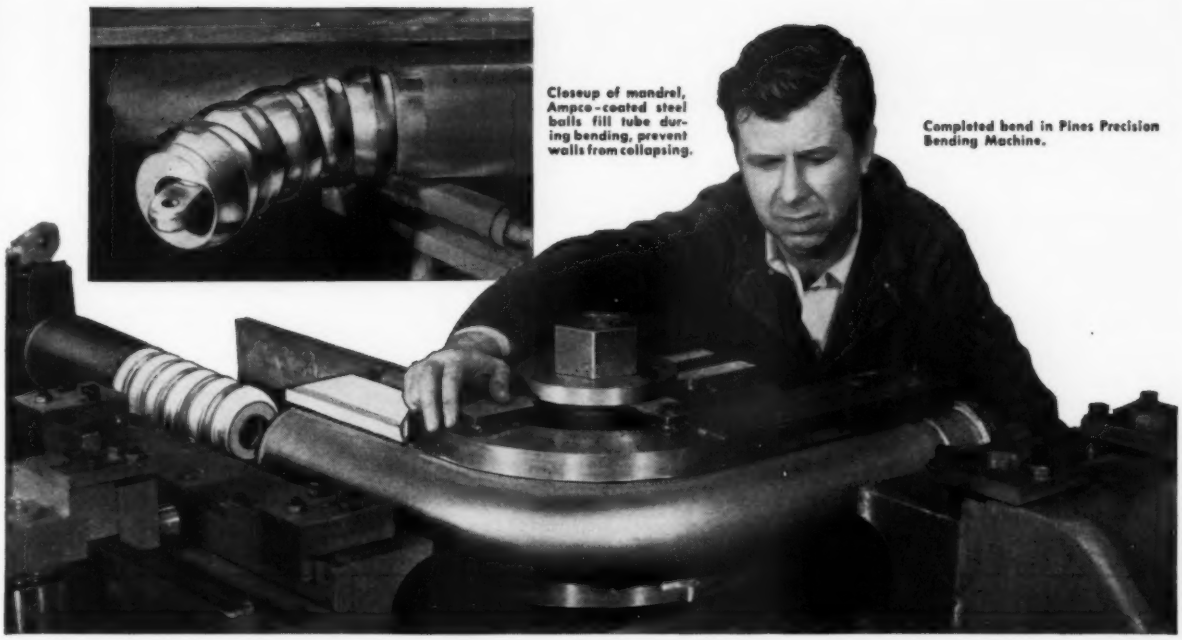
a. Surface roughness does not seriously influence the fatigue strength of these alloys. At constant surface hardness the relationship between fatigue limit and surface roughness is a curve which is concave upward. The fatigue limit falls off gradually and at a decreasing rate with increasing roughness.
b. For constant values of surface roughness the relationship between fatigue limit and surface hardness is approximately linear (as in the case of steels, for example).
c. A given change in surface roughness lowers the mean value of the fatigue limit more at high hardnesses than at low hardnesses.

4. The fatigue-strength reduction factor (ratio of fatigue limit for a smooth specimen to fatigue limit for a notch specimen) is approximately equal to the theoretical stress-concentration factor for the notch. Comparison applies only to fatigue limits of smooth and notched specimens having similar surface preparation in the test section.

5. No heating effect caused by internal friction was observed in the RC 130B or Ti 140A titanium alloys investigated.

6. Failure by fretting fatigue appears to be a more serious problem in the titanium alloys than in other commercially available structural metals.

From a paper entitled "Effect of Surface Finish on the Fatigue Strength of Titanium Alloys RC 130B and Ti 140A" presented at the ASME Annual Meeting in Chicago, November 1955.



Closeup of mandrel, Ampco-coated steel balls fill tube during bending, prevent walls from collapsing.

Completed bend in Pines Precision Bending Machine.

Pines Engineering licks "impossible" job

. . . bends ultra-thin stainless tubing

. . . cuts airplane costs $14,000

***thanks to* AMPCO* METAL**

AIRCRAFT engineers said that cold bending of thin-wall tubing sections for engine and airframe components was impossible — that it couldn't be done. But Pines Engineering Co., Aurora, Illinois, went to work anyway. It developed a precision bending machine that makes smooth, sharp bends to 10″ centerline radius in up to 5″ diameter x .025″ wall stainless tubing — bends that are cutting airplane costs up to $14,000 each.

Pines selected Ampco Grade 20 wiper dies and Ampco-coated mandrels for their new precision machine to resist the tremendous pressures developed in this bending operation. Here's what they say:

"Ampco eliminates the problem of pickup on the mandrel and wiper die when bending stainless steel tubing. And Ampco provides a hard-wearing surface that enables the production of thousands of bends before dies have to be refitted."

And if you draw, form, or bend stainless, pickled carbon steel — or many other metals — here's what *you* get with Ampco dies:

Little or no pickup. You eliminate all the expense of redressing steel dies — redressing that is necessary because of scratching, galling, or pickup. Idle time is cut — and your line keeps moving at top production.

Low finishing costs. You end galling, loading, scratching, die marks. No more problems with big scrap losses. You reduce expensive finishing time.

This remarkable copper-base alloy pays off on your drawing or forming line with longer life, lower costs, less operating grief. Get all the facts on cost-saving Ampco dies from your nearby Ampco field engineer or mail the coupon.

Tear out this coupon and Mail Today!

LET AMPCO PROVE ITS ~~METAL~~ *mettle*

AMPCO®

Sole producer of genuine Ampco Metal

*Reg. U. S. Pat. Off.

Ampco Metal, Inc.
MILWAUKEE 46, WISCONSIN
West Coast Plant • Burbank, California

Ampco Metal, Inc., Dept. MD-4, Milwaukee 46, Wisconsin

I'd like to know more about time- and money-saving Ampco dies. Please send me more information.

Name..... Title.....

Company.....

Company Address.....

City..... (.....) State.....

D-39A

—ITEM 620—
For More Information Circle Item Number on Yellow Card—page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Sleeves & Way Protectors

Illustrations and schematic drawings are used in bulletin MIS-56 to show available types and commonly accepted methods of installing pliable sleeves and way protectors to operating parts of equipment and machines. 1 page. A&A Mfg. Co.

—Circle ITEM 401

Air Seal & Cycle Timer

Speed and accuracy of an air-operated press can be increased by application of the Rotorseal combination rotary air-seal and cycle timer. As described in illustrated bulletin ML-135, it automatically controls passage of air to pneumatic clutch and brake at preset cycles. 4 pages. Fawick Corp., Fawick Airflex Div.

—Circle ITEM 402

Beryllium Copper Strip

"Specifying Beryllium Copper Strip" is title of bulletin 6 which discusses available alloys, tempers, sizes, properties and tolerances. Also described is Penntemp mill-hardened beryllium copper strip that requires no heat treatment. 12 pages. Penn Precision Products, Inc.

—Circle ITEM 403

Data on Ceramics

Technical data on eleven ceramic materials are given in chart-type bulletin "Ceramic Materials." General characteristics and typical applications as well as design considerations are tabulated. 6 pages. Carborundum Co., Stupakoff Div.

—Circle ITEM 404

Special Wire Shapes

Technical bulletin T-2 describes line of special shaped wire in a variety of nickel alloy and stainless steel compositions. Available shapes, sizes, properties and applications are discussed. 4 pages. H. K. Porter Co., Alloy Metal Wire Div.

—Circle ITEM 405

Pneumatic Regulators

Precision-made pneumatic regulating equipment such as filter-regulator combinations, filters and regulators, relays, purge assemblies and control panels are described in bulletin H-3. Dimensional drawings and application data are given on these controls for pressure, vacuum, differential, ratio and reversal. 8 pages. Conoflow Corp.

—Circle ITEM 406

Electric Motors

Complete design and application information on open drip-proof, enclosed and explosionproof electric motors made to the new NEMA standards is contained in bulletin 1700. Also described are special motors to meet the wide variation in industry requirements. Louis Allis Co.

—Circle ITEM 407

Couplings & Clutches

Developed for permanent and releasing applications, Curvic couplings are available in fixed, semiuniversal and releasing types in wide range of sizes. These high capacity, accurate units are described and applications are shown in illustrated bulletin. 16 pages. Gleason Works.

—Circle ITEM 408

Explosive Valves

Line of explosive valves detailed in illustrated bulletin 5501-XV operates instantly upon the firing of a self-contained explosive squib. Normally-open and normally-closed types are available for pressures up to 5000 psi. 4 pages. Conax Corp., Explosive Products Div.

—Circle ITEM 409

Industrial Resins

Rubber compounding, cements, wood bonding, brake lining, grinding wheels, abrasive papers, insulation bonding, casting resin, electrical parts, laminating and sealing porous castings are some of the subjects covered in illustrated guidebook "Industrial Resins." 12 pages. Durez Plastics & Chemicals, Inc.

—Circle ITEM 410

Electronic Components

Specifications and dimensional drawings for line of rotating servomechanism components and adjustment and setting tools are found in illustrated bulletin 362. Included are synchro transmitters, 2-phase servo motors, synchro receivers, induction motors and collector rings. 16 pages. Norden-Ketay Corp., Precision Components Div.

—Circle ITEM 411

Miniature Potentiometers

Miniature low-torque, micro-miniature and miniature precision wire wound potentiometers for commercial use are subject of the Aerohm data sheet. Resistance ranges from 10 to 100,000 ohms. Complete engineering data are given. Waters Mfg. Co.

—Circle ITEM 412

Stainless Solenoid Valves

The latest additions to the Gould line of stainless steel solenoid valves for fluid control purposes are covered by illustrated bulletin K. Normally-open and normally-closed types are offered in 1¼, 1½ and 2-in. sizes with coils for any electrical operating condition. 4 pages. J. D. Gould Co.

—Circle ITEM 413

Disk Thermostats

Available styles of Stemco type D bimetal disk thermostats for operation up to 300° F are described in bulletin LL-2120. Design data listed include operating principle, performance, ratings, dimensions and mountings. 2 pages. Stevens Mfg. Co.

—Circle ITEM 414

Fiber Products

Vulcanized fiber and thermosetting plastic parts designed to withstand wear are shown in illustrated bulletin "For Wear Applications." Included is data sheet on copper clad Spauldite for printed circuit use. 6 pages. Spaulding Fibre Co.

—Circle ITEM 415

Carbon & Graphite Products

Carbon and graphite products and molded mechanical rubber products for industrial, transportation and appliance use are described in plastic-bound catalog. Henrite Co.

—Circle ITEM 416

Carbon & Alloy Steels

Chart shows approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels. Hardness systems covered are Brinell, Monotron,

a combination . . . for game!

laminated plastics . . . a combination of properties for trouble-shy designers

When a man goes a-hunting for a material for a specific application, he wants one that satisfies his own combination of property requirements . . . *and is easy to machine.* Synthane laminated plastic is just the material—*plenty* of good mechanical, electrical, electronic and chemical properties . . . combined with excellent machining and fabricating characteristics.

Synthane terminal insulators must meet high property and machining standards. They must have high dielectric strength in a machinable insulator, good moisture resistance, excellent arc resistance, good heat resistance and mechanical strength. This insulator and similar parts can be fabricated at the Synthane plant with no waste, no problems to the purchaser.

DIELECTRIC STRENGTH

HIGH STRENGTH-TO-WEIGHT RATIO

EASILY MACHINED

DIMENSIONAL STABILITY

. . . send for complete catalog and fabricating data.

SYNTHANE

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

—ITEM 621—

For More Information Circle Item Number on Yellow Card—page 19

Helpful Literature

Vickers and Rockwell B, C and E. 2 pages. Babcock & Wilcox Co., Tubular Products Div.

—Circle ITEM 417

Flexible Conveyor Belt

Details of the new Omniflex flexible conveyor belt for materials handling and product processing are given in illustrated data sheet 256. It is available in steel and stainless and has inside turning radius of 2½ times the belt width. This open mesh belt has smooth flat surface. 2-pages. Ashworth Bros., Inc.

—Circle ITEM 418

Precision Gears

Detailed data on gear and axle shaft lines which include spur, helical, spiral bevel, hypoid, straight bevel, Zerol, flywheel ring gears and spline shafts are included in illustrated brochure. Available equipment to produce each type is discussed. 8 pages. Detroit Bevel Gear Co.

—Circle ITEM 419

Electroplating Data

Handy wall chart on heavy cardboard is intended as aid in costing and other operations connected with precious metal electroplating. It tells at a glance the related and comparative data on gold, rhodium, palladium, platinum, silver and nickel. Technic Inc.

—Circle ITEM 420

Purge Meters

Versatile designs of Brooks-Mite and Sho-Rate purge meters for constant small flow of liquids or gases are shown in illustrated bulletin 120. Included are application data, design and construction details and capacity charts. 8 pages. Brooks Rotameter Co.

—Circle ITEM 421

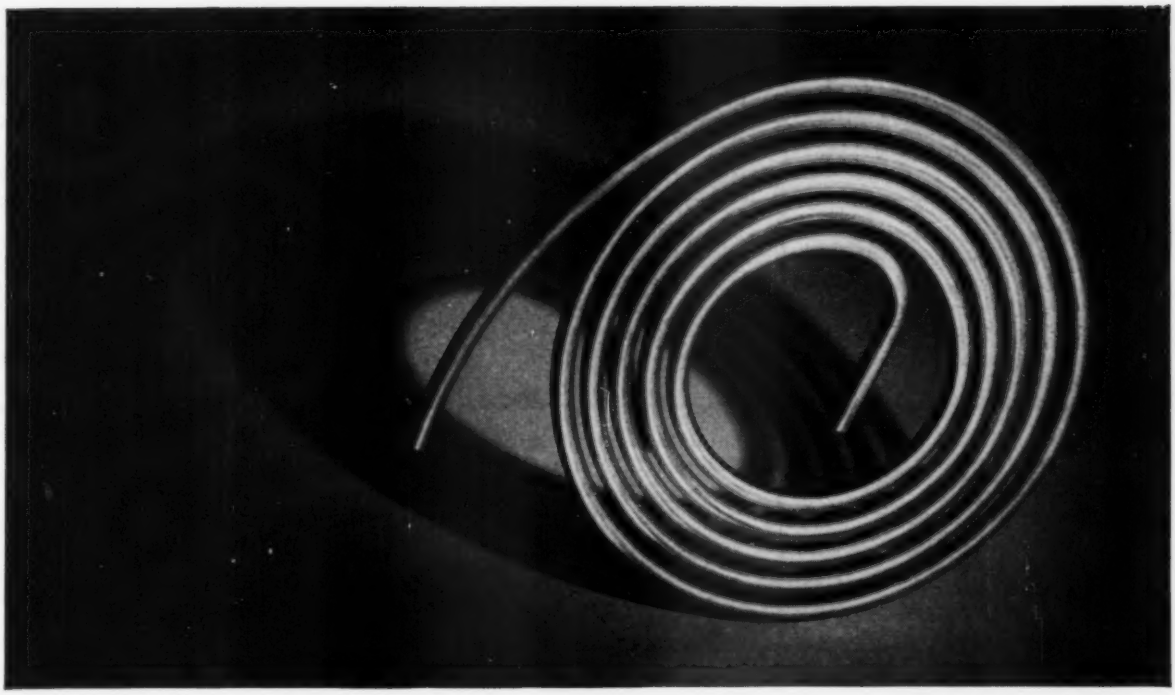
Valve Positioner

Throttltrol automatic valve positioner, detailed in bulletin F 5991-1, corrects for variations in heat requirements due to changes in furnace load, control settings, air and fuel pressure, BTU values or combustion efficiency. Use is with control instrument having high and low contact with neutral position. 2 pages. Barber-Colman Co., Wheelco Instruments Div.

—Circle ITEM 422

Perforated Materials

Hundreds of different standard patterns of perforated materials are illustrated in actual size in general catalog No. 62. Hole sizes, centers



Superior offers the widest range of sizes and alloys in top quality instrument tubing

Superior Tube Company produces the finest instrument tubing in a wide range of sizes and alloys—offers you as standard products what many makers would classify as specialty tubing.

1. NEEDLE TUBING

The stainless steel links in this recording instrument are made of Superior needle tubing. The high strength, stiffness, and strict dimensional tolerances characterizing this tubing—originally designed for surgical uses—have opened new fields of industrial applications when used as mechanical tubing.

2. PRESSURE AND SUPER PRESSURE TUBING

A spiral windpipe made of Superior 304 cold-drawn seamless stainless steel tubing. Pressure tubes are used to convey fluids at elevated temperatures and pressures. Produced in stainless, carbon and alloy steels in sizes to withstand pressures up to 100,000 psi.

3. BOURDON TUBING

A "C" tube element for a pressure gage. The shaped Bourdon tube serves as the actuating element for the majority of pressure indicating and recording instruments. Helix and spiral elements are also fabricated from the wide range of alloys available at Superior—a range that makes it possible to satisfy any set of conditions in the use of Bourdon tubing.

4. CAPILLARY TUBING

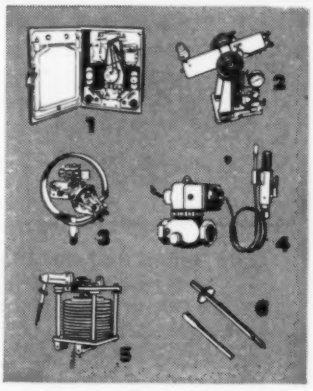
A thermostatic instrument pressure transmission element with a coiled unit made of Superior Type 321, capillary tubing. Superior capillary tubing is used primarily for transmitting temperature and pressure impulses from the source to a recording or indicating instrument. Capillary purposes, in general, require a heavy-wall tube with an ID of .006" to .030". Types 347, 321, 316, MONEL* and carbon steels are recommended analyses.

5. LARGE OD LIGHT WALL TUBING

A large OD light wall tubing bellows in a pressure actuating element. Present applications for large OD light wall tubing include bellows, low pressure heat exchanger tubes, flexible hose, aircraft ducting, fractional horsepower motor casings, ceramic drills, and casings for radioactive well logging instruments. Sizes offered up to 2½" OD.

6. MECHANICAL TUBING—INSTRUMENT LINE

Various fabricated parts—all made of Superior mechanical tubing. Superior mechanical tubing can be either seamless or WELDRAWN† grade used statically or dynamically, but not subjected to severe temperature or pressure. It is produced in sizes up to ⅝" OD within production limits, in many special shapes, and in over 63 standard analyses and mechanical properties.



Send for free copy of Bulletin 40—A Guide to the Selection and Application of Superior Tubing. Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to ⅝" OD—certain analyses in light walls up to 2½" OD

On the West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif.

*Reg. T.M. International Nickel Co.
†Reg. T.M. Superior Tube Co.

—ITEM 623—

Helpful Literature

and per cent of open area are given and other sizes of standard patterns are listed in tables. 128 pages. Harrington & King Perforating Co.

—Circle ITEM 423

General Purpose Grease

Molykote type BR2 general purpose lithium-base grease with extreme bearing pressure properties, is subject of bulletin 101. Ten outstanding qualities and physical specifications are given. 2 pages. Alpha Molykote Corp.

—Circle ITEM 424

Reinforced Plastic

Advantages, applications and procedures for using Scotchply reinforced plastic are described in illustrated reference manual. Sixty-two illustrations show possible uses in various industrial fields. Charts give mechanical, electrical, chemical resistance and thermal properties. Also included are instructions for molding and handling. 20 pages. Minnesota Mining & Mfg. Co.

—Circle ITEM 425

Shock Mountings

Series of Met-L-Flex industrial shock and vibration mountings which feature all-metal construction, resilient cushions and engineered mountings is covered in illustrated bulletin 1000. Selection factors, selection guide, typical applications and specifications are given. 8 pages. Robinson Aviation, Inc., Industrial Div.

—Circle ITEM 426

Xerography Copying

How the xerography copying process is saving the Chrysler Corp. $250,000 yearly is related in this illustrated folder. Engineering drawings, reports, manuals, textbooks, office forms, press releases, correspondence and other materials are reproduced. 4 pages. Haloid Co.

—Circle ITEM 427

Cabinets for Electronics

Representative type metal cabinets, cases, housings and enclosures produced by company are illustrated in folder EC-354. Piece points up company's capacity to follow through from original design to full finishing operations. 4 pages. Artisan Metal Works Co.

—Circle ITEM 428

AC-DC Test Units

Units for over-potential testing and power supply use, along with standard meters, high voltage voltmeter, shunts, transformers, phase sequence

Don't Let These Filing Bottlenecks Stall Drafting Room Output!

File units for roll tracings are available. Individual trays protect each roll from dirt, tearing, and crushing.

Let Your Bruning Man Show You How a Hamilton UnitSystem

Saves Space and Time, Permits Orderly Expansion

UnitSystem is Integrated to Save Time and Space. UnitSystem offers you an integrated and interlocking stack in which your drawings and records are filed in units especially designed for them by size and frequency of use. Drawings are easier to file and find, which saves time. The interlocking feature lets you combine the individual units you need—in higher stacks—which saves space.

The Shallow-Drawer Unit with special tracing lifters makes any active tracing easily accessible without risk of damage to companion tracings. Vertical Filing Unit with index binders and compressors keeps active small sheets straight and upright without wrinkling or tearing. Five-Drawer Unit provides ideal storage for semi-active or inactive drawings and records by groups or projects.

UnitSystem is Expandable for Future Needs. Because all UnitSystem files in the same line number are matched and interlocking, you expand your filing set-up gradually, efficiently, and economically. From a complete line of units, you choose those that exactly meet your requirements as they arise.

Mail coupon today for more information on the important savings offered you by lifetime all-steel UnitSystem files.

Ask your Bruning representative for information about the Bruning-Hamilton free analysis and planning service for improving your filing system—or use coupon below. No obligation.

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—ITEM 625—

Helpful Literature

indicators and other electrical-electronic equipment comprise line announced in catalog 55G-U. This data-packed handbook is compiled for proper unit selection. 20 pages. Davenport Mfg. Co.

—Circle ITEM 429

Stainless Bellows

Newly formed Bellows Div. of this company is now producing Airite stainless steel bellows, compensating chambers, tie rod units to absorb line thrust and other components of ducting assemblies. Bellows range from 1½ to 8 in. ID. Added information is offered in bulletin 3480. Airite Products, Inc.

—Circle ITEM 430

Low Delivery Air Pump

Dexter-Conde Dri-Air pump designed for low delivery requirements at pressures from 20 in. mercury to 10 psi is covered along with air filters in new bulletin. Data are given for twelve operating conditions ranging from 3.5 to 33.2 cfm. Air filter section describes open-end model for air intake at filter and in-line model for installation in vacuum lines between intake and pump. Dexter Folder Co.

—Circle ITEM 431

Weld Rupture Properties

Technical data card 178 tabulates stress-rupture properties of chromium-nickel stainless steel weld deposits. Data pertain to design of stainless tubular products in steam superheaters, heater coils and high-temperature piping installations. 2 pages. Babcock & Wilcox Co.

—Circle ITEM 432

Rubber Products

Custom-molded rubber products including commercial and fuel-resistant O-rings, seals and miniature O-rings are specified in products catalog. Service recommendations and typical test reports are highlights. 24 pages. Stillman Rubber Co.

—Circle ITEM 433

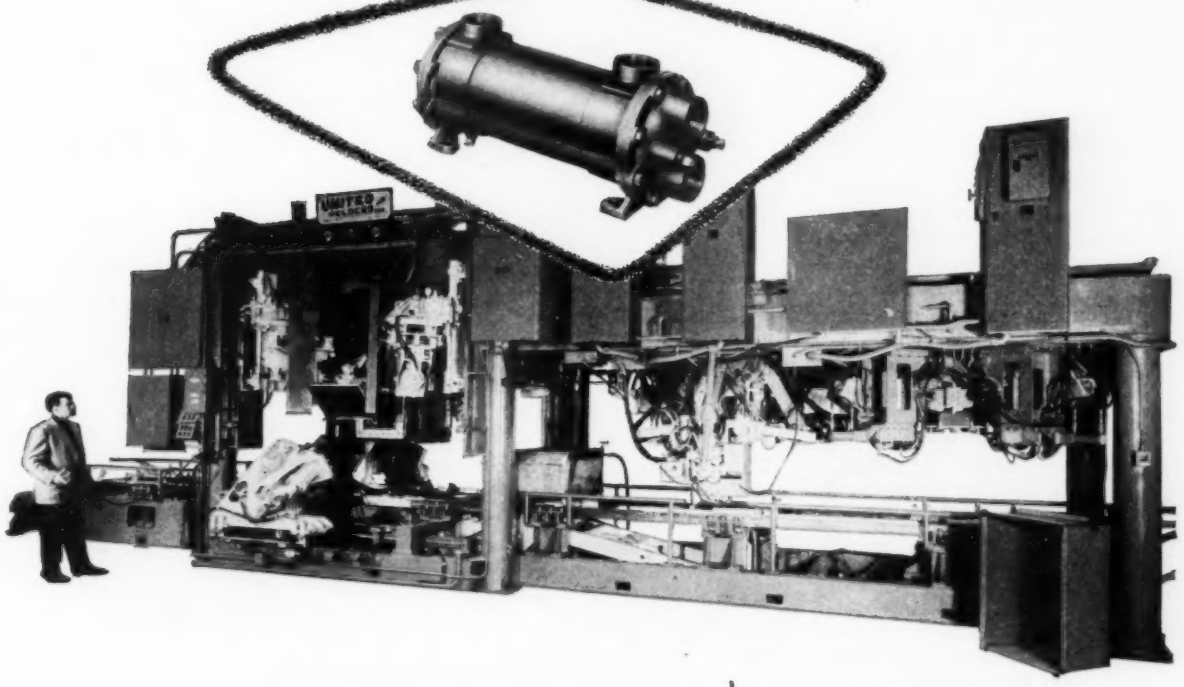
Aluminum Bronzes

Basic information is provided in booklet 15.100-1 on properties, composition and functions of "W W Premium Quality Aluminum Bronzes" as furnished in sand, centrifugal, investment and permanent mold castings; forgings; and heat-treated and machined parts. A spec chart identifies each grade with Government and technical societies specifications. 28 pages. W W Alloys, Inc.

—Circle ITEM 434

ROSS EXCHANGER

cools oil while this United Welder mass-produces 200 refrigerator liners per hour



Completely automated, this United Multi-Station, Seam, Spot and Projection Welder transfers, locates, folds and welds 200 refrigerator liner assemblies per hour.

To maintain constant seam weld carriage speeds by preventing pump slippage from overheated, thinned oil, a Ross Type BCF Exchanger has been installed as original equipment. Although high pressures are developed in the folding and clamping operations, hydraulic oil temperatures won't vary from the "norm." *Efficient cooling is assured!*

The Ross Exchanger was selected, according to United Welders, Inc., "because it is economical, dependable and easy to maintain". Installing Ross Exchangers has become a regular habit of numerous manufacturers building hydraulic machinery of every description. It's the sure way of providing the utmost in thermal efficiency without expensive "specials" in either engineering or fabrication.

Rugged Ross Type BCF Exchangers are pre-engineered and fully standardized in a wide range of sizes to meet most needs.

For detailed information, request Bulletin 1.1K5.

ROSS

EXCHANGERS

ROSS HEAT EXCHANGER DIVISION
of
American-Standard

1429 West Avenue • Buffalo 13, N. Y.
In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.

—ITEM 627—

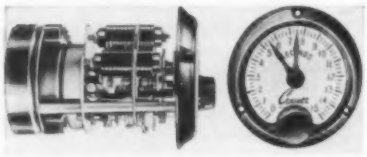
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Time Delay Relays

repeat within 0.25 per cent on 30-sec range

Full-vision black-on-white dials permit fast accurate setting of types 412 and 422 time delay relays. Repeatability is ± 0.25 per cent of full scale on 30-sec and longer ranges, ± 0.5 per cent on faster ranges. Silver-cadmium contacts have quick-make, quick-break wiping action and are rated at 15 amp. Nine-position terminal block permits wiring from side or back. Friction setting mechanism can be adjusted while timer is operating.



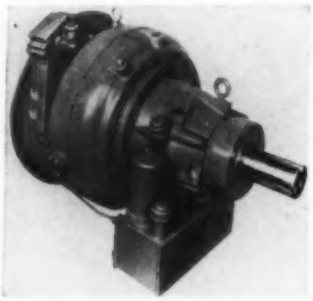
Type 412 timer automatically resets on power failure and recycles when service is restored; type 422 incorporates a reverse-action clutch which causes it to suspend operation in case of power failure, resuming and completing the same cycle when service is restored. **R. W. Cramer Co. Inc.**, Centerbrook, Conn.

—Circle ITEM 461

Torque Converter

adaptable to engines in 60 to 600-hp range

Variety of input and output shaft arrangements are available in ten different models of this Series 13,800 three-stage torque converter. It can be adapted by the factory to engines in the 60 to 600-hp range by a change in internal blading. Input arrangements include



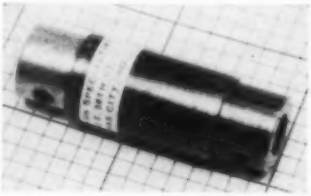
a spider drive which withstands normal misalignments without imposing undue loads on the engine crankshaft, a clutch assembly, and an independent mounting system. Torque multiplication at stall is 6:1. The unit is designed to fit new SAE standard flywheels, and accommodates 0 and 00 housing sizes. Converter is also available in three additional series for engines in the 40 to 1000-hp range. **Twin Disc Clutch Co.**, Hydraulic Div., Rockford, Ill.

—Circle ITEM 462

Subminiature Clutch

transmits torques to 15 oz-in.

Measuring 1¼-in. long and 5/16-in. diam, this subminiature positive-displacement clutch transmits up to 15 oz-in. torque at speeds to 1800 rpm without external lubrication. Moment of inertia is extremely low, making the unit suitable for applications requiring fast response under high loading. Maximum drag torque is 0.5 oz-in. It is available with either coupling-end or through-shaft mountings. **Precision Specialties**, 1342 E. 58th St., Kansas City 10, Mo.

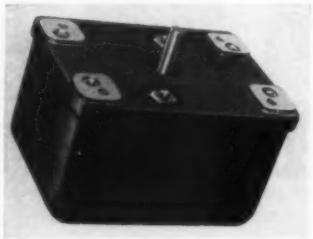


—Circle ITEM 463

Rotary Solenoid

has low power consumption

Series 400 rotary solenoid develops 12 lb-in. torque on 115-v, 60-cps input (40-per cent duty cycle). Operating time of solenoid is approximately 0.020 sec. Continuous intermittent duty types are available, with 20, 30, 45 or 60-deg maximum rotation. Totally enclosed, the units have complete environmental protection. Class H insulation permits high-temperature use. Bronze bearings and high-carbon steel shaft provide long life. **Leetronics Inc.**, 30 Main St., Brooklyn 1, N. Y.



—Circle ITEM 464

Gear Drives

are rated from 11 to 150 hp

Adaptable to any vertical turbine pump and driven by gasoline or diesel engines, these Holloshaft right-angle gear drives are now available in ratings from 11 to 150 hp. Reverse protection clutch prevents damage to the pump and

Motor Burnouts *are preventable!*

U. S. MOTOR WINDINGS

Asbestos-Insulated to resist burnouts

Eliminate causes and avoid failure

Extensive surveys reveal the astonishing fact that a large percentage of motor burnouts occur from *avoidable* causes such as overload, clogged passages or confined spaces, improper circuit protection and bearing failure. These conditions, if not corrected, result in overheating of the windings. Ordinary insulations are organic and will carbonize when excessively heated, resulting in motor burnout.

As a means of increasing motor life and to resist burnouts the windings in U.S. motors are insulated with inorganic *asbestos*, greatest of heat-resisting elements and Nature's only incombustible fiber.

Asbestos is used in sheet form to separate the windings and in a compounded form, vibro-applied, as a filler to completely isolate each wire. Coil ends are further protected with a built up armor of several coatings of an asbestic compound that smooths the surface and forms an impervious protection against moisture.

In Bulletins portraying the outstanding features of U.S. Uniclosed, Varidrive, Syncrogear and Totally-Enclosed motors, the application of asbestos is interestingly presented, proving its life-lengthening characteristics. Get these Bulletins. Mail the Coupon.

U.S. *Electrical* MOTORS

Mail Coupon Today ▶

U. S. ELECTRICAL MOTORS Inc. MD-4

P.O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.

Send Booklet(s) showing advantages of asbestos-protection in

☐ Uniclosed Motors ☐ Varidrives

☐ Totally-Enclosed Motors ☐ Syncrogear Motors

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

—ITEM 628—

For More Information Circle Item Number on Yellow Card—page 19

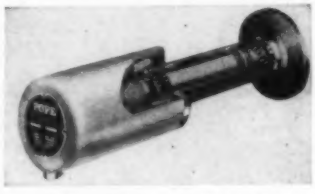
drive in the event of accidental engine reversal, and weatherproof construction protects the drive from dirt and moisture. Positive lubrication is provided for all moving parts; oil circulation to the thrust bearing is verified through a sight gauge window. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

—Circle ITEM 465

Precision Spindle

has independent radial and thrust bearings

Totally enclosed and nonventilated, this 1 hp, 3600 rpm surface-grinder spindle utilizes double-row cylindrical roller bearings and separate thrust bearings to prevent shaft end play. Power input is 3-



phase, 60 cycle ac. Intended for application in precision grinding equipment, the spindle is also available with high-speed vertical and horizontal grinding attachments. **Pope Machinery Corp.**, Haverhill, Mass.

—Circle ITEM 466

Silicone Finish

for heat-cleaned glass cloth

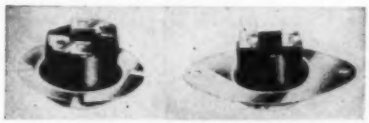
Designated T-31, solution of silicone in methyl cellosolve is used as a finish for heat-cleaned glass cloth in structural laminates. Effective with epoxy, phenolic, polyester and silicone resins, it enables laminators to meet a number of specifications with a single type of finished glass cloth. Cloth is dipped into diluted T-31 and oven-dried. No washing or neutralizing is required. Concentration required depends upon characteristics of the cloth and speed of equipment used. The finish is stable as supplied and does not separate or settle out after standing. It requires no buffering prior to application. **Dow Corning Corp.**, Midland, Mich.

—Circle ITEM 467

Thermal Switch

has snap-action disk

Designed for low-cost application in home appliances, air conditioners, heating equipment, etc., series 202 Klixon thermostat incorporates a simple snap-action calibrated disk and contact arrangement. Temperature settings range from −10 to 350 F, and sensitive element can



be enclosed for protection against dirt and lint or exposed for faster thermal response. Electrical rating is ½ hp or 25 amp noninductive at 120 v, ac. Terminals are either quick-connect or screw type, and different combinations of flanges and terminals are available. **Metals & Controls Corp.**, Spencer Thermostat Div., Attleboro, Mass.

—Circle ITEM 468

Terminal Strip

is designed for printed circuit computers

This subminiature terminal strip, designated MB, is available in 6 and 10-contact types for printed-circuit computer applications. Two mounting holes on the body of the strip permit stacking in a small area. One side of the strip accommodates AMP Series 53 taper tab for solderless wiring. The other side is suitable for conven-

it's

CRUCIBLE REXALLOY

for abrasion, corrosion and heat resistant parts...with better finish

1. One of a pair, this blade of REXALLOY A shears hot glass during manufacture of TV tubes. Liquid cooled between operations, it offers maximum resistance to wear, corrosion, and thermal shock. REXALLOY blades outperform previously used high speed steel shears by a wide margin.

2. Nozzle for jet type oil well rock bit cutter. Made of REXALLOY 51, it stands up exceedingly well under severe cold abrasive conditions encountered in drilling oil wells.

3. Extrusion die insert of REXALLOY 33. Inside contours are cast within a few thousandths of finished size. REXALLOY inserts produce as many as six to ten times as many pushes as conventional hot work tool steel extrusion dies.

Here's what Crucible REXALLOY means to you: Castings of high hardness, even at elevated temperatures . . . excellent resistance to both corrosion and abrasion . . . smooth, clean finish.

What's more, REXALLOY castings, when made by the shell-mold process, can be cast to any shape. Dimensions are held to closer tolerances than ever before . . . practically all machining and grinding operations are eliminated—especially important with hard super-alloys like REXALLOY.

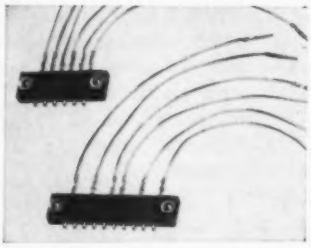
So if your application calls for a part with one or more of these characteristics, REXALLOY shell-molded castings are the answer. They are moderate in price (less than investment castings), closer in dimensions and finish than conventional castings. Let your Crucible representative give you the complete story of what they can do for you. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

—ITEM 630—

New Parts



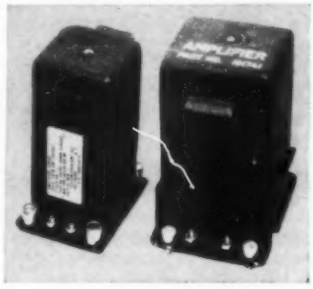
tional wiring. Body material is mineral-filled type MME Melamine which meets MIL-P-14D specifications. Brass contacts are gold plated over silver for low contact resistance and soldering ease. **DeJur-Amsco Corp.,** Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

—Circle ITEM 469

Servo Amplifiers

in 2, 4 and 10-w ranges

Ruggedized plug-in servo amplifiers for 400-cycle control system are hermetically sealed and incorporate the latest miniaturization techniques. Designed to meet applicable military specifications, the units are available in 2, 4 and 10-w ranges. Companion line of 400-



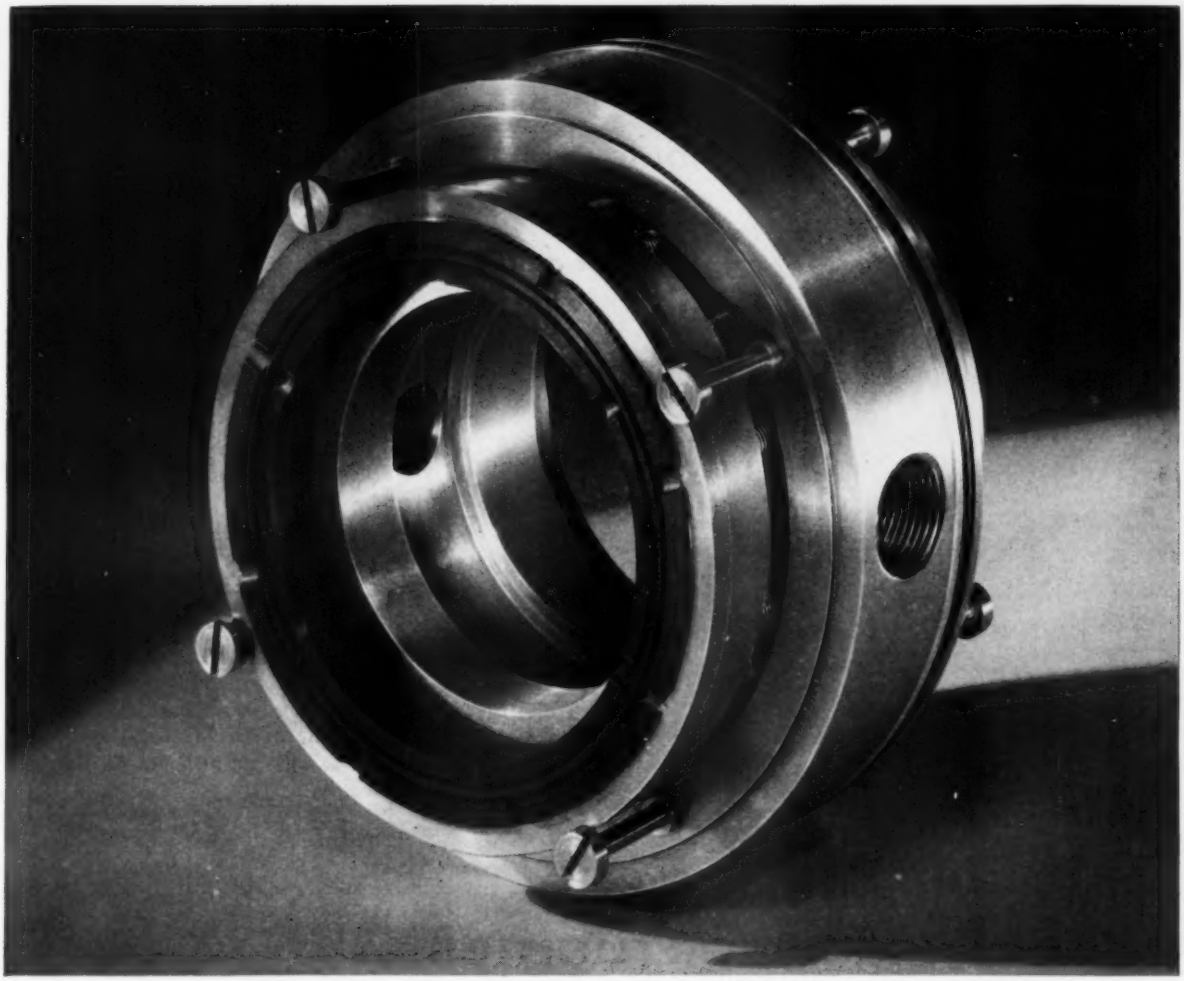
cycle power supplies and modulators is also available. **Servomechanisms Inc.,** Eastern Component Div., 625 Main St., Westbury, L. I., N. Y.

—Circle ITEM 470

Sun Battery

provides power for transistorized units

Selenium sun battery converts solar energy into electrical power. Applications include use as a power supply for transistorized units such as portable radio receivers



Koppers Face Type Seal Provides Up to 20,000 Hours of Service!

Up to 30,000 Hours in Laboratory Tests Using Clean Gas!

Koppers engineering has created an unmatched sealing surface that gives Koppers Face Type Seals a much longer-than-ordinary service life.

The exclusive design of the sealing surface keeps pressure distribution and hydraulic balance unchanged during operation . . . permits a light face loading which lowers interface temperatures. Hydraulic balance allows sealing of gases and liquids through a wide range of rubbing speeds. Rugged construction adds to Koppers long service life. Rotating collars can be of hardenable stainless steels, cutlery and die steels, Stellites, or of a hard chromium or carbide face. Ring is of carefully selected grades of carbon.

If you have a sealing or piston ring problem, Koppers entire research, production and engineering facilities are at your disposal. For more details, write to the KOPPERS COMPANY, INC., 2304 Hamburg St., Baltimore 3, Maryland.

Koppers Company, Inc.
Metal Products Division
Piston Ring and Seal Dept.

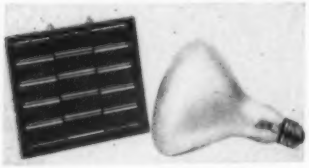
***Engineered* Products**
Sold with *Service*

KOPPERS®

MECHANICAL SHAFT SEALS

New Parts

and transmitters. When exposed to bright incident sunlight of approximately 10,000 foot-candles, output power of battery is 5 mw per active sq in. at an output volt-



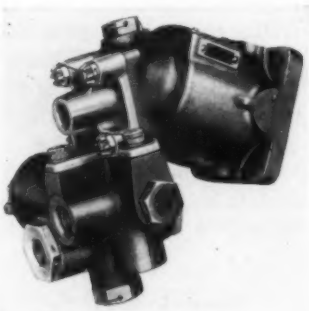
age of 0.26 v per sensitive element. The battery shown has 15 photosensitive elements connected in series. Output voltage is about 4 v at maximum power transfer operation and 8 v under open-circuit condition. Operating temperature is 85 C continuous duty, 100 C intermittent duty. The battery has long life and exhibits little aging when operating within its rated conditions. **International Rectifier Corp.,** Product Information Dept., 1521 East Grand Ave., El Segundo, Calif.

—Circle ITEM 471

Hydraulic Motor

provides constant-speed drive in either direction

Designed for use in aircraft oil-hydraulic systems, this new two-direction motor incorporates an integral flow control to prevent runaway action or overspeeding. Since both inlet and return flows are metered, motor overloading is avoided, and constant-speed drive in either direction of rotation is obtained. Op-



eration can be continuous, intermittent, or stalled without damage to the unit when the system is protected by the proper overload relief valve. Volumetric efficiency

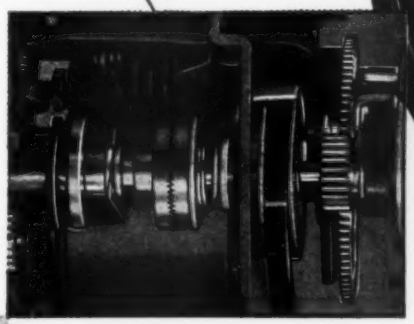
NEW

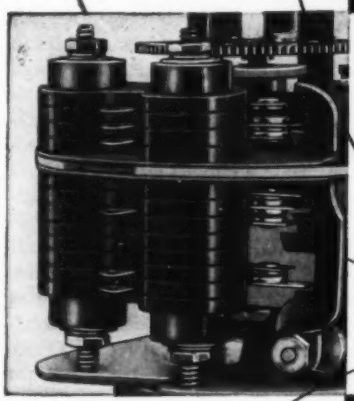
from face to terminal block

Cramer

type 412

TIME DELAY RELAY





NEW—Repeat Accuracy within ± ¼ of 1% of full scale (30 sec. and longer ranges); ± ½ of 1% on faster timers.

NEW—Full Vision Dial. 300 degree scale assures precise settings and fast, accurate readings. Dial and pointers protected by transparent cover.

NEW Contacts, rated 15 amps., give positive quick-make, quick-break operation. Contacts are of silver cadmium oxide with ability to handle high inrush currents.

NEW Flexibility in wiring. Nine-position terminal block offers side or rear connection, presents a variety of wiring possibilities.

NEW Reset Shock Spring Design laboratory tested for more than a million operations.

NEW Friction Setting Mechanism allows adjustment even while timer is operating.

NEW—Ratchet Clutch operated by powerful relay, provides instant action, no slip.

NEW O-Ring Retainer permits quick removal of bakelite housing, exposing entire timer mechanism.

Timer driven by high torque (30 in. oz. at 1 r.p.m.) Cramer Type 112 Synchronous Motor.

Cramer TIMING DEVICES

The R. W. CRAMER CO., Inc.

SPECIALISTS IN TIME CONTROL

BOX 6, CENTERBROOK, CONNECTICUT

18CR

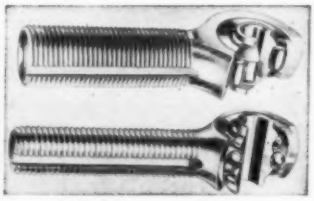
New Parts

at maximum operating speeds is approximately 96 per cent. Designed for operating pressures to 3000 psi, the motor can be provided with torques to 150 lb-ft and speeds to 9100 rpm (intermittent). **Vickers Inc.**, 1400 Oakman Blvd., Detroit 32, Mich.

—Circle ITEM 472

Rod Ends

have balanced design for high capacity and light weight



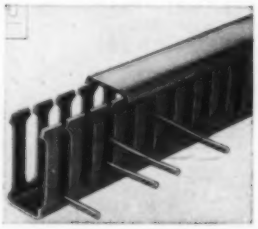
Design of new series self-aligning ball and roller-bearing rod ends provides balance of shank strength, bolt strength and bearing capacity without excess weight or useless capacity. Ultimate tensile strength of alloy steel outer rings and shank is 125,000 psi minimum; inner rings are SAE 52100 steel, through hardened. Permissible bearing misalignment is 10 deg in either direction, and shanks withstand load angularities up to 9 deg. Ball-bearing units (2 sizes) are intended for manually-operated aircraft control systems; roller-bearing models (3 sizes) are suited for use with booster-powered controls. **Fafnir Bearing Co.**, New Britain, Conn.

—Circle ITEM 473

Control-Panel Conduit

has slotted design to reduce wiring time

Wires in this plastic wiring duct are simply snapped in and out, thereby reducing wiring time. Lugs can be attached before the wire is inserted and wire can be



THIS WAS FORGED FOR ECONOMY

Recent developments in steel forging techniques have made possible remarkable economic changes. Cameron Split-Die forgings of high quality alloy steel are produced in intricate shapes with both internal and external contours and in sizes from 200 to 5,000 pounds.

Many man-hours of production time are saved, machining difficulties are diminished and, of course, cost is reduced.

WRITE *Cameron*

IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

—ITEM 636—

For More Information Circle Item Number on Yellow Card—page 19

New Parts

removed with lugs attached. Fastener with internal bolt and nut arrangement holds both duct and cover. Plastic duct effectively insulates wiring and is not affected by moisture or heat. It is available in 1 x 1-in. to 3 x 3-in. sizes in 5-ft lengths. **Panduit Co.,** Dept. MDC, 10132 S. Washtenaw Ave., Chicago 43, Ill.

—Circle ITEM 474

Nonslipping Belt

accurately transmits rotational motion

Herringbone indexing belt is constructed of neoprene to ensure resilience of the belt-teeth. Tooth error of the gear is integrated over all of the teeth engaging the belt, thereby averaging any re-

sidual error inherent in the driving gears. V-shaped tread of the belt wedges continuously to center the belt in the corresponding V-tread of the gears engaged. Associated gears are constructed without belt-restraining rims. The belt is available in a limited number of sizes. **Electromation Co.,** Kinevox Div., Burbank, Calif.

—Circle ITEM 475

Plug Valve

is injection molded of polyvinyl chloride

Designed to handle a variety of corrosive fluids, this PVC valve has Teflon bearing buttons on the plug to provide self-lubrication. Straight-through port makes possible unimpeded flow. The valve has either threaded or socket-type ends for solvent welding. It can be used as a substitute for valves of special alloys, stainless steel,

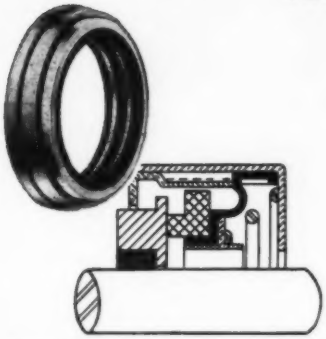
—ITEM 637—
For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 638→

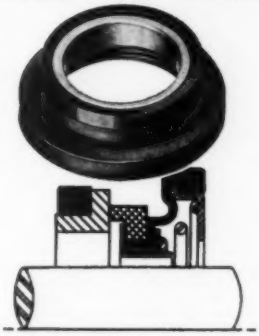
LARGEST STOCK SELECTION AVAILABLE ANYWHERE!

Modern, Mechanical, Face-Type Seals —
Standardized, To Save Time And Money

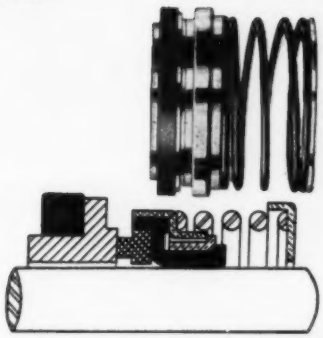
YOUR Sealing Problem Is Solved Here!



STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Important applications in machine tools and power transmission equipment. Stock sizes for shafts .250 through 4.000.

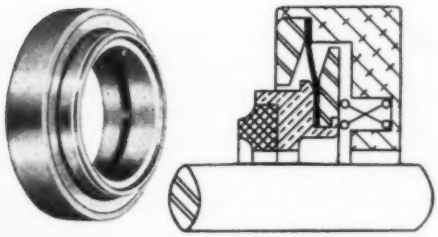


STYLE SGU—A factory-assembled unit-type seal for the small budget user. Widely used in appliance field. Stock sizes for shafts .250 through 1.000.

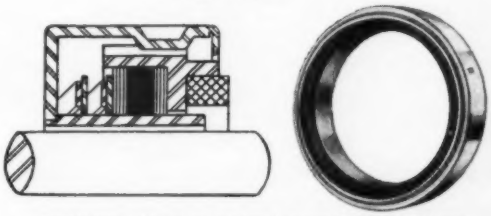


ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Many applications in pumps and compressors. Stock sizes for shafts .250 through 4.000.

STYLE RFO—A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



STYLE DPC — A high-speed, carbon-faced seal, for use where lubrication is poor or where shaft RPM and resulting friction are high. Ideal in many machine tool applications. Stock sizes for shafts .250 through 4.000.



STYLE HH—Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Of particular importance to the aircraft industry. Stock sizes for shafts .250 through 4.000.

These are only a few of the countless sealing problems now being solved by

GITS SHAFT SEALS

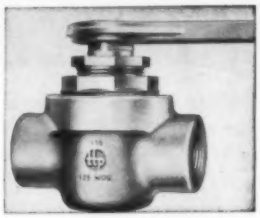
Write for detailed data on any of these standardized stock Gits Shaft Seals.

GITS BROS. MFG. CO.

1868-A S. KILBOURN AVE. CHICAGO 23, ILL.

Specialists In Lubricating Devices And Shaft Seals For Almost Half A Century

New Parts



other plastic materials or those lined with glass, porcelain, stoneware or hard rubber. Valve is available in 1, 1½ and 2-in. sizes. **Tube Turns Plastics Inc.**, 2929 Magazine St., Louisville 11, Ky.

—Circle ITEM 476

Miniature DC Motor

has planetary gears and brake

Compact dc planetary-geared motor with brake is furnished with lead configurations, shaft lengths, and shaft diameters to meet customer requirements. Specifications are: voltage, 25-29 v dc; current, 0.40 amp; speed, 27± 7 rpm (free and under load); stopping angle of output shaft, 3 deg maximum. Model 1700-1 motor has aluminum case and all shafts are ball-bearing sup-

ported. Military environmental specifications are satisfied. **El Ray Motor Co. Inc.**, 11747 Vose St., North Hollywood, Calif.

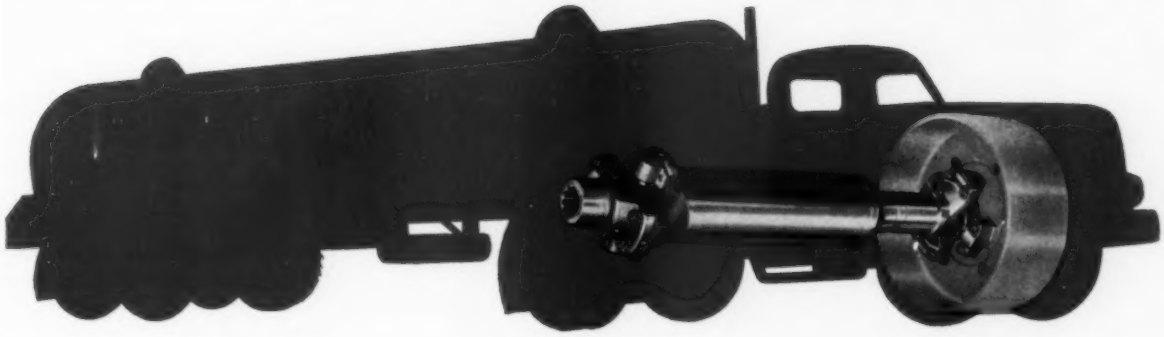
—Circle ITEM 477

Quick-Disconnect Coupling

can be disconnected under pressure without fluid loss

Suitable for hydraulic and pneumatic systems with pressures to 1500 psi and flow rates to ½ gpm, this quick-disconnect coupling can be uncoupled under pressure without loss of fluid. Material is anodized aluminum; size is 2 3/16-in. overall length by 0.95-in. diam; threads are ⅛-in. ANPT, male and

RUGGED



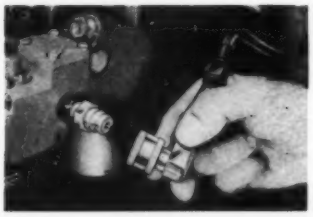
Manufacturers of the big diesel transports, that must stand up under hour-after-hour of gruelling service, have learned to rely upon MECHANICS Roller Bearing UNIVERSAL JOINTS to deliver hundreds of thousands of miles of trouble-free service. Because MECHANICS JOINTS drive through KEYS—instead of bolts—they stand up under punishment that shears off other types of fasteners. They are designed with less parts and connections for easy assembly and servicing—smooth running balance—maximum strength with less weight—and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS Roller Bearing UNIVERSAL JOINTS. Let MECHANICS engineers help you design this and other competitive sales features into your product's transmission train.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
79 E. Adams, Chicago 3, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

New Parts



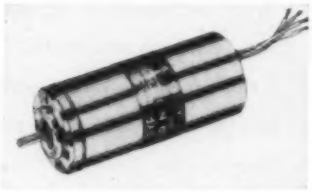
female. Special units can be supplied to customer order in other threads, different flange construction or alternate materials. **Eastern Industries Inc.**, 100 Skiff St., Hamden 14, Conn.

—Circle ITEM 478

Geared Servo Motor

has a backlash of 0.5-deg

Designed for 400 cps operation at either 115 or 26 v, size 11 geared servo motor can be provided with output speeds from 6 to 1275 rpm. Integral gear train uses miniature precision ball bearings throughout, and backlash can be specified as 0.5-deg or less. Normal stall torque of motor without gearing is 0.63 oz-in.; no-load speed is 6200 rpm. With gearing, stall torque



ranges from 3.3 to 60 oz-in., depending on output speed. Diameter is 1.062 in. and lengths vary to 2.219 in. maximum. **G-M Laboratories Inc.**, Components Div., 4300 N. Knox Ave., Chicago 41, Ill.

—Circle ITEM 479

Connector

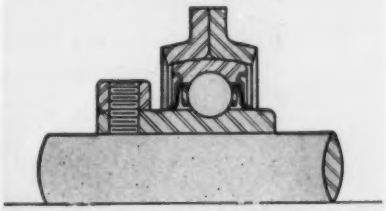
designed for limited-space installations

Rack and panel type DPE assembly has 40 contacts rated at 10 amps. Shell is extra shallow for installation where space is limited. Contacts for No. 16 stranded wire are housed in a Melamine No. 1502 insulator. Overall length of

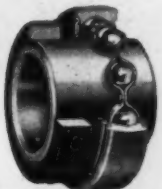
MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

THIS NEW HOLLAND HAY BALER is typical of equipment on which JPS-200 ball bearing pillow blocks are popularly applied.

SELF-ALIGNING. Free-rolling and full load capacity of the JPS-200 ball bearing pillow block are maintained even with shaft deflection or misalignment.



MAXIMUM SEALING EFFICIENCY. Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Greased at factory ready for operation.



SINGLE-ROW, DEEP-GROOVE standard Series 200 ball bearing is used. Extra-long inner ring assures proper load distribution—heavy spring locking collar firmly secures bearing on shaft.

Low cost Compactness Self-alignment

Link-Belt JPS-200 ball bearings combine all three

HERE is a new concept in bearing design—a proven answer to the economy needs of many equipment manufacturers. And most important—this JPS-200 Series ball bearing pillow block achieves low cost without sacrifices in bearing design.

The standard, full-capacity, self-aligning Series 200 ball bearing is supported in a rugged, pressed steel housing. Further economies result because the JPS-200 arrives in *one piece*—ready for fast, foolproof installation. And standard dimensions plus extreme compactness are added aids to the designer.

Ask any one of 40 Link-Belt offices for Folder 2517 containing complete information on the JPS Series. And get Book 2550 for data on Link-Belt's complete ball and roller bearing line.

LINK-BELT

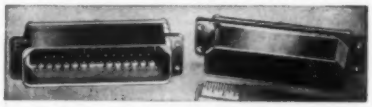
Ball and Roller Bearings

Rugged, steel-clad JPS-200 Series — from industry's most complete line of ball and roller bearing pillow blocks.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13.355-A

New Parts

shell is 3 15/16 in., and shell material is diecast aluminum to afford protection for the insert and contacts. Corner key design pro-



vides positive polarization. Flashover is rated at 1700 v, 60 cps ac at sea level. Weight of mated connector is 0.381-lb. **Cannon Electric Co.**, 3209 Humboldt St., Los Angeles 31, Calif.

—Circle ITEM 480

Tachometer Generator

for servo systems

Miniature 115-v ac unit for 60-cycle circuits has been developed for use as feedback element in closed-looped servos and in industrial applications. It can be integrally coupled to servo motors with outputs of 1, 5 or 10 w and can be used to regulate the speed of a servo motor. With 100,000 ohm resistive load, output is 6 v per 1000 rpm. Phase shift can be

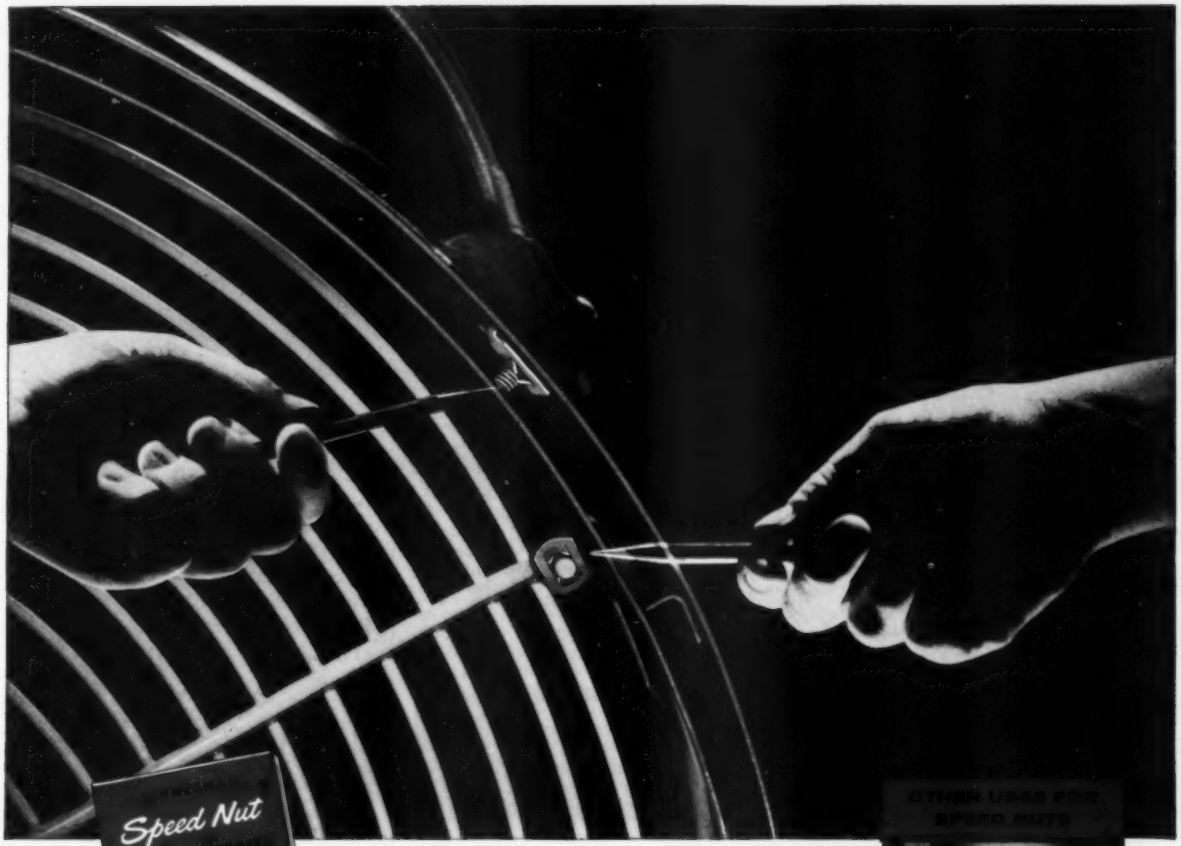
brought to zero by capacitive load at any desired speed; maximum variation in phase shift between 0 and 3600 rpm is 3 deg. Residual voltage is 100 mv maximum. **Diehl Mfg. Co.**, Finderne Plant, Somerville, N. J.

—Circle ITEM 481

Magnetic Switch

operates at switching rates to 200 per second

Model MH-2 high-speed switch is actuated by the proximity of a magnetic field at switching rates to 200 cycles per second. When



37% cost saving in production, 28% saving on assembly with Tinnerman SPEED NUTS®!

It takes only 5 Tinnerman SPEED NUTS to cut costs on the Atlas-Aire Utility Fan, manufactured by the Atlas Tool and Manufacturing Company, St. Louis.

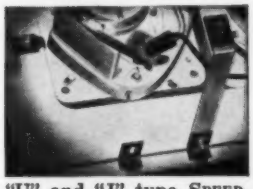
Two "J" Type SPEED NUTS make a lightning-fast, vibrationproof attachment of carrying handle to fan housing. Three Push-On SPEED NUTS firmly secure the grill to the housing.

Twelve parts were eliminated to bring about a 37% cost saving; total assembly time has been reduced from 25 to 18 minutes to effect a 28% time saving. The elimination of a spot welding operation and a punch press also resulted in a better use of over 400 square feet of floor space!

Your Tinnerman representative can offer you over 8,000 different shapes and sizes of SPEED NUT brand fasteners to produce similar fastening savings in your product assemblies. Call him, or write for your free copy of "SPEED NUT Savings Stories."

TINNERMAN PRODUCTS, INC. • BOX 6688, DEPT. 12, CLEVELAND 1, OHIO
Canada: Dominion Fasteners, Limited, Hamilton, Ontario. *Great Britain:* Simmonds Aerocessories, Limited, Treforest, Wales. *France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine). *Germany:* Hans Sickinger GmbH "MECANO", Lemgo-i-Lippe.

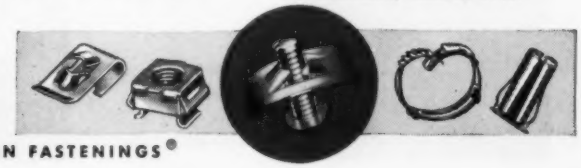
Jet-convector heater manufacturer uses "U" and "J" type SPEED NUTS, reduces assembly time by 50%.



"U" and "J" type SPEED NUTS designed into new gas range gain 50% assembly time saving.

On this ceiling light, special SPEED NUT replaces 3 parts, cuts assembly time by 80%!

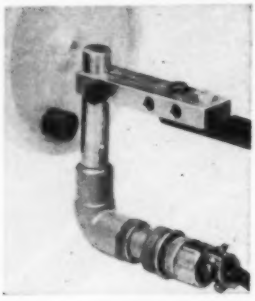
TINNERMAN *Speed Nuts*



FASTEST THING IN FASTENINGS®

—ITEM 644—

New Parts



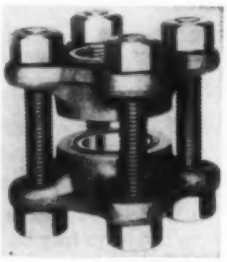
a magnet is moved close to the face of the switch, the switch arm makes contact; as the magnet moves away, the switch arm returns to normal position. Contacts are single-pole, double-throw and are rated at 5 amp, noninductive. Life is in excess of 30-billion cycles. **Post Machinery Co.,** Electronic Products Div., 150 Elliot St., Beverly, Mass.

—Circle ITEM 482

Flange Unions

are O-ring sealed

Tight seal against fluid pressure is provided by O-rings in this forged-steel flange union. Two and four-bolt models are available in both screw-end and socket-welding styles. Ratings are up to 3000 psi, and sizes range from ¼ to 1¼



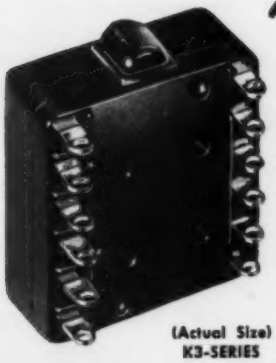
in. (two-bolt) and 1 to 2 in. (four-bolt). O-ring material can be specified to suit service conditions. **H. K. Porter Co. Inc.,** W-S Fittings Div., P. O. Box 95, Roselle, N. Y.

—Circle ITEM 483

Rotary Solenoid Valve

has no reciprocating parts

Low-leakage rotor assembly in this two-position hydraulic valve is actuated by a continuous-duty rotary solenoid. Input is 95-125-v, 60 cycle ac, and solenoid can be



(Actual Size)
K3-SERIES

TRIPLE-POLE SWITCH

OPERATING CHARACTERISTICS

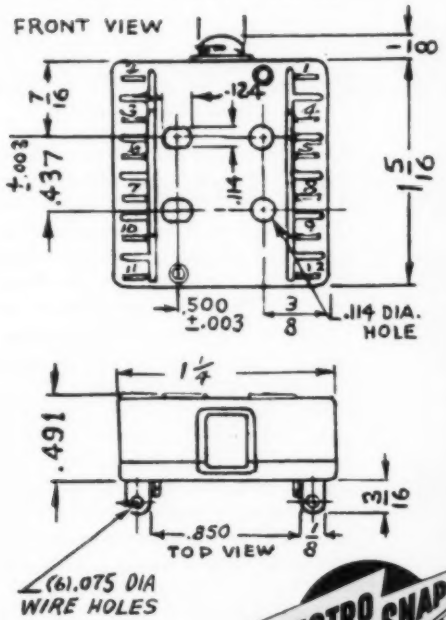
CONTACT ARRANGEMENTS:

K3-4—TRIPLE-POLE, DOUBLE THROW
K3-2—TRIPLE-POLE, NORMALLY OPEN
K3-1—TRIPLE-POLE, NORMALLY CLOSED

ELECTRICAL RATING:

15 AMP 125/250 V.A.C.
15 AMP 30 V.D.C. RESISTIVE
10 AMP 30 V.D.C. INDUCTIVE

PROBABLE MECH. LIFE.....1,000,000 OPS
PROBABLE ELEC. LIFE..... 500,000 OPS
AMBIENT TEMP. RANGE.....—100° TO +275° F.*
*(—100° to +375°F. available)



New ELECTRO SNAP SIMULTANEOUS TRIPLE-POLE SWITCH

for interrupting 3-phase,
110 V, 400 cycle AC circuits

6-CIRCUIT CONTROL — in a small package.
Makes possible a wide variety of circuit combinations.

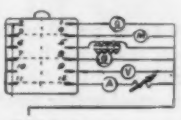
SIMULTANEOUS "MAKE & BREAK" ACTION
Permits unusual applications, reduces arcing, prolongs switch life and increases electrical capacity.

This completely new Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous snap-action of the three poles is independent of the speed of actuation — even extremely slow moving cams can be used.

The K3-Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

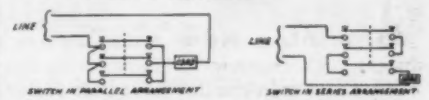
LOOK WHAT YOU CAN DO WITH IT!

Control Six Circuits with ONE Snap



Used in motor control device switch, when actuated, turns on the red light on No. 1, the solenoid on No. 5, the voltmeter on No. 9 and turns off the motor on No. 4, the green light on No. 8 and the furnace and ammeter on No. 12.

Wire Movable Poles in Series for High Voltage or in Parallel for High Current

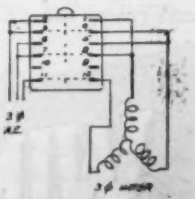


With the switch wired in parallel arrangement, the current is divided into 3 paths through the switch. This permits the switch to be used with a load rated up to 3 times the ampere rating of the switch.

With the switch wired in series arrangement, the current has only 1 path through the switch. The multiple breaks in the current path permits the switch to be used where the line voltage is rated up to 3 times the voltage rating of the switch; ampere rating not affected.

Start and Stop Three-Phase Motors

Completely disconnect all current supplied to a 3-phase motor by interrupting 3 phases simultaneously with one snap.



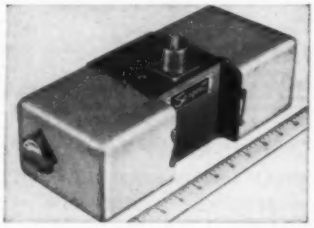
ELECTRO-SNAP
SWITCH AND MFG. CO.
4214 West Lake Street • Chicago 24, Illinois

MODERN DESIGN IN A COMPLETE LINE OF SWITCHES

—ITEM 647—
For More Information Circle Item Number on Yellow Card—page 19

New Parts

energized indefinitely at 165 F. Shaded poles reduce alternating current hum. Intended for use where high reliability is mandatory, the valve withstands high-impact shock without change in setting. Ambient temperature limits are −20 to 165 F, and line-pressure ratings are 1500 or 3000 psi. Valve is supplied with manual override and can be solenoid actu-



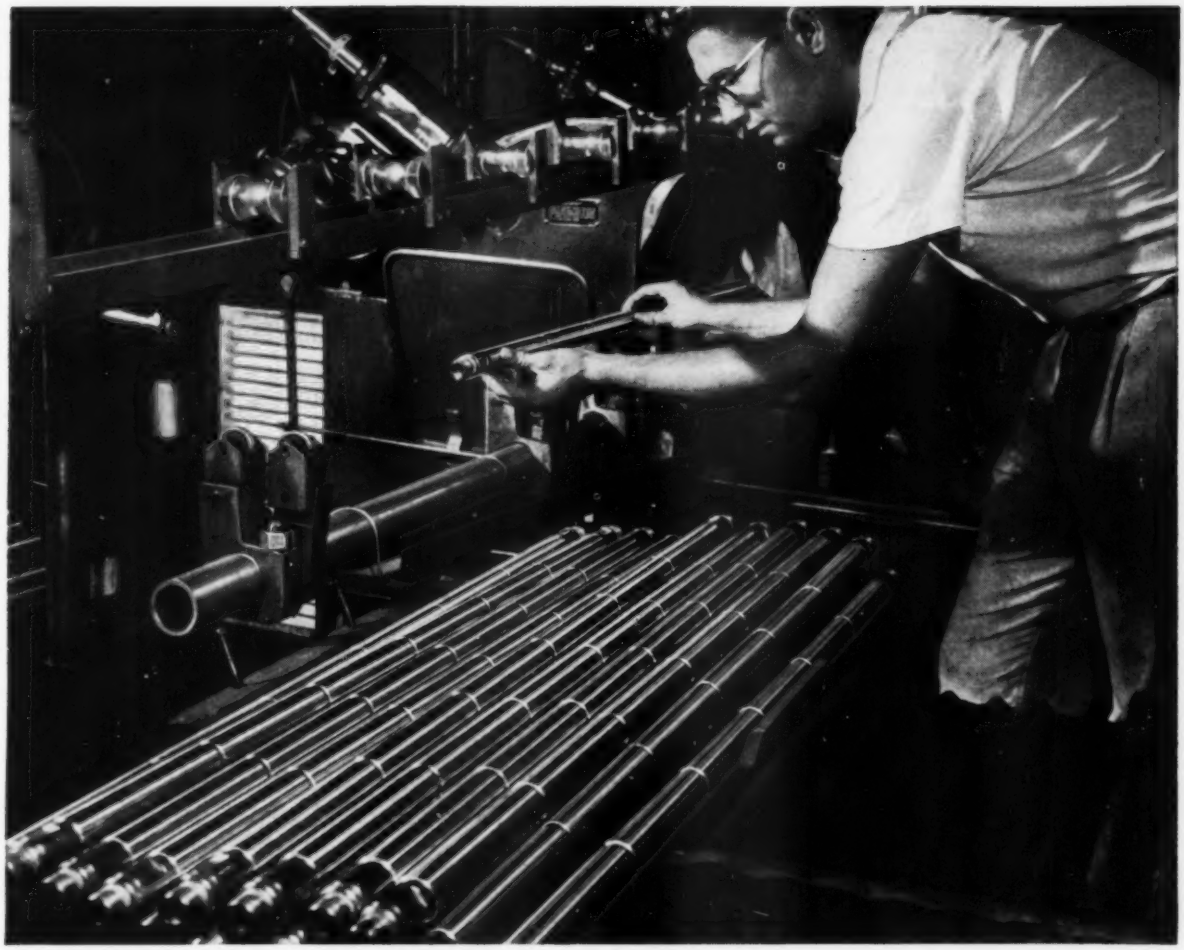
ated in both directions or solenoid actuated with spring return, depending on the user's requirement. Capacity is 1.5 gpm at 200-psi total pressure drop. **Sargent Engineering Corp.**, 2533 E. 56th St., Huntington Park, Calif.

—Circle ITEM 484

Ring-Type Rheostat

resists mechanical shock

For use where severe mechanical shock is encountered, N152 ring-type rheostat has windings secured by a silicon coating to separate the turns and protect the wire. High dielectric strength of the base, core, and collector-ring support assemblies is provided by the glass-bonded mica construction. The beryllium copper contact arm is locked directly to the insulating hub, providing uniform contact pressure and eliminating backlash. Rating is 50 w (continuous duty), resistance tolerances is +20 −10 per cent, and maximum resistance value is 20,000 ohms. The unit



THREE SIZES OF TUBING IN ONE PUMP ... PRECISELY!

Like so many products, the deep well reciprocating pump manufactured by Fluid Packed Pump Company of Los Nietos, California, is practically all tubing with the exception of fittings used on the end. And because the pump's components are received as tubes—semi-finished products in themselves—they require much less fabrication than would otherwise be necessary.

For the past 10 years, this company—an acknowledged leader in its field—has used B&W seamless alloy steel mechanical tubing for its product which pumps oil up from subsurface areas of wells. The barrel and plunger of the pump are precision parts which must be held to extremely close tolerances if they are to function properly. The uniform size, wall thickness and concentricity characteristics of B&W Tubing, with its surfaces free from spiral, scratches and pits, combine to make this tubing ideally suited to the Fluid Packed Pump operation.

A closer look at your own product, from both a design and fabrication standpoint, may reveal opportunities for tubing applications that may save time and money and improve your product. Whatever your requirements, B&W Tubing—carbon, alloy or stainless—can meet them. Call Mr. Tubes, or write for Technical Bulletin 365. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA-5024M

Seamless and welded tubular products, seamless welding fittings and flanges—in carbon, alloy and stainless steels

—ITEM 649—

New Parts

meets MIL-R-15109 and the shock requirements of MIL-S-901. On order, type N152 rheostats can be supplied wth tapered windings, shaft extensions, and tandem mountings. **Ward Leonard Electric Co.**, Mount Vernon, N. Y.

—Circle ITEM 485

Subminiature Potentiometer

actuated by a 25-turn lead screw

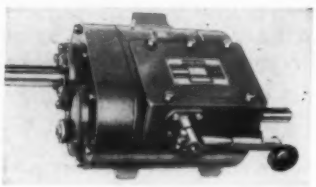
Linearity of RWT subminiature trimmer potentiometer is ± 5 per cent, standard; accuracy of total resistance is ± 10 per cent. Temperature coefficient of resistance wire is 0.0017 per cent per degree C, providing resistance stability over a temperature range from −55 to 95 C. Resistance values available range from 50 to 15,000 ohms. Compact size permits ten RWT units to be installed in space less than 1 cu in. One-quarter turn of 25-turn stainless-steel lead screw, which positions the dual-wiper sliding contact, changes the resistance setting by 1 per cent. Applicable military specifications are met by the enclosure, consisting of an anodized aluminum body and stainless-steel cover. **Technology Instrument Corp.**, 531 Main St., Acton, Mass.

—Circle ITEM 486

Transmission

has torque capacity of 865 lb-in.

Forward and reverse transmission with clutch control, designated model 17100, has a maximum



XUM

You can set a new High Torque Unbrako self-locking socket set screw and forget it—it stays tight

There are several reasons: the deeper socket which gives you better purchase with the wrench; the rounded socket corners which eliminate the sharp corners where cracks start; the special methods of heat treatment in atmosphere-controlled furnaces; the development of fully formed threads.

Up to 40% higher tightening torque—a new Unbrako feature

RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES (Inch-Pounds)

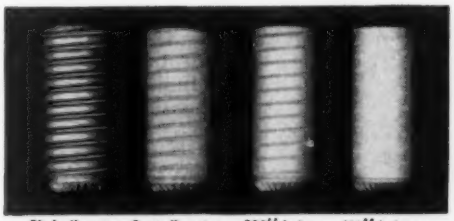
SCREW SIZE	UNBRAKO	SET SCREW B	SET SCREW C	MINIMUM DIFFERENTIAL %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
1/4	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
1/2	620	460	500	24
5/8	1225	1106	1060	11
3/4	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

ALL UNBRAKOs can withstand higher tightening torques than ordinary set screws. For example, the recommended torque for a ¼" UNBRAKO is 87 inch-pounds—40% greater than that recommended for an ordinary set screw.

These microphotographs illustrate just what fully formed threads do for the new High-Torque UNBRAKO. They make the whole screw stronger. The metal is compressed into the closely knit grain structure that you see. The grain flow follows the contour of the threads. There are no straight lines along which shear can occur. The UNBRAKO retains its flow lines even when ground down to .010" below root diameter. Screws with cut or ground threads lose thread form at root diameter.

You can't buy a better set screw than an UNBRAKO. See your authorized industrial distributor today. Or write STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

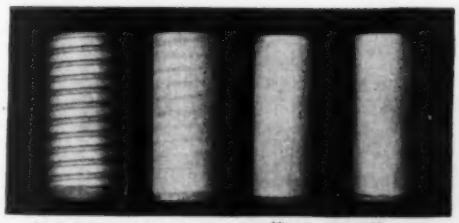
Unbrako Set Screw



Pitch diameter | Root diameter | .005" below root diameter | .010" below root diameter

Fully formed threads make the whole screw stronger. The metal is compressed into a closely knit grain structure. The grain flow follows the contour of the threads. The UNBRAKO retains its flow lines even when ground down to .010" below root diameter. Screws with cut or ground threads lose thread form at root diameter.

Ordinary Set Screw



Pitch diameter | Root diameter | .005" below root diameter | .010" below root diameter

STANDARD PRESSED STEEL CO.

UNBRAKO SOCKET SCREW DIVISION SPS JENKINTOWN PENNSYLVANIA

—ITEM 652—

New Parts

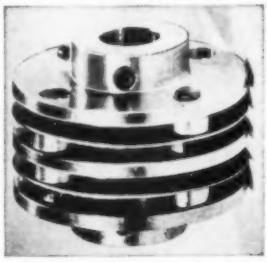
reduction of 3:1 and torque capacity of 865 lb-in. Gears and shafts are of heat-treated alloy steel; gear teeth are shaved. Revolving shafts operate on antifriction bearings, and lubricant is held in case. Shift is obtained through a conveniently located shifting lever. Weight is approximately 120 lb. **Western Mfg. Co.**, 3400 Scotten Ave., Detroit 10, Mich.

—Circle ITEM 487

Flexible Coupling

accommodates shaft misalignment to 6 deg

Accommodating shaft diameters from ⅛ to 5/16 in., model C-300 flexible coupling transmits substantial torques between shafts



that are misaligned as much as 6 deg. It is suitable for applications requiring back-lash free connection of rotating shafts. **Oerlikon Tool & Arms Corp.**, P. O. Box 3049, Asheville, N. C.

—Circle ITEM 488

Insulation Block

resists temperatures to 2300 F

Lightweight, bonded ceramic fiber block for high-temperature insulation is chemically inert, withstands direct flame inpingement, and has high compressive strength. Designated F-20, the block has a density of about 20 lb per ft^3 and deforms 1 per cent under a 4.47-psi load (ASTM test C 165). Thermal conductivity is 1.27 at a mean temperature of 1000 F; at 2000 F, conductivity is 2.24. Modulus of rupture is 48 psi. Standard sizes are available from 12 x 12 in. to 36 x 12 in.; thicknesses range from 1½ to 4 in. **Carborundum Co.**, Niagara Falls, N. Y.

—Circle ITEM 489

CUT COSTS

with the Original Mead

MIDGET AIR CLAMP

(Spring Return Air Cylinder)

In assembly jigs and other multiple applications, this new, low cost pressure unit saves countless man-hours. As a work-ejector in many fixtures, it is unexcelled.

Only $3.95 EITHER STYLE ($40.80 Per Dozen)

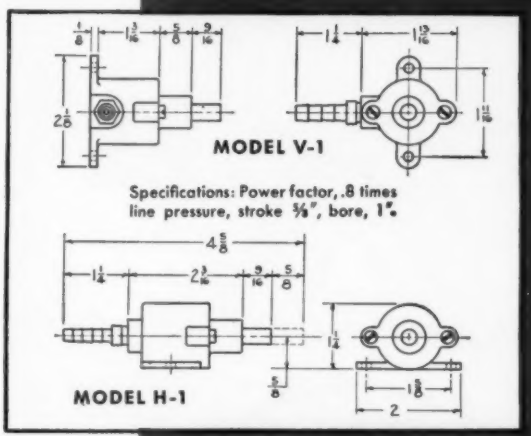
Advantages over mechanical clamps

1. **All Air Clamps** in any set-up can be operated by a single master valve—the "lock-up" and release of assemblies is instantaneous.
2. **May be installed in cramped corners** difficult to reach with bulky mechanical clamps. Mead Midget is the most compact air cylinder, for its power, on the market.
3. **Equal ram pressure at any point** along stroke, making special, delicate adjustments unnecessary.
4. **Independent group control.** Any desired group of "Midgets" can be controlled independently of any other group in an assembly—as where primary members of the fixture must be locked up before the secondary members.
5. **Facilitates delicate drill operations.** Air Clamps actuated by foot control valves leave operator's hands free to handle the work pieces.

Send for all the interesting facts on these time-tested, superior Midget Air Clamps.

MEAD SPECIALTIES COMPANY

4114 North Knox Avenue • Dept. MD-46 • Chicago 41, Illinois



IMMEDIATE DELIVERY

Single-acting cylinders delivered from stock; double-acting in a few days.

Fill Out MEMO Coupon Now For

***New* MEAD INDUSTRIAL AIR POWER CATALOG**

MEAD

Air Operated Devices

Memo Coupon

MEAD SPECIALTIES CO.

4114 N. Knox Ave., DEPT. MD-46, Chicago 41, Illinois

Send free copy of new, colored MEAD INDUSTRIAL AIR POWER CATALOG describing the complete line of famous Mead air-operated devices.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

—ITEM 654—

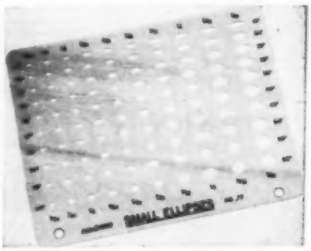
ENGINEERING DEPARTMENT

EQUIPMENT

Ellipse Template

in 10 projections from 15 to 60 deg

Made of 0.020-in. amber plastic, this No. 73 small ellipses template has 100 precision-milled ellipses



in 10 projections from 15 to 60 deg. Template measures 6 x 4¾ in. **Rapidesign Inc.,** Box 592, Glendale, Calif.

—Circle ITEM 490

Eight-Channel Recorder

is compact and self-contained

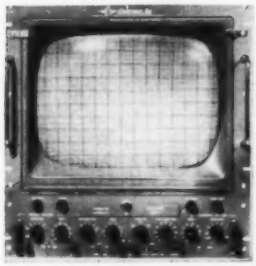
Completely self-contained, Model 158-5490 eight - channel oscillographic recording system is housed in a mobile, 46-in. cabinet. Dual-channel dc amplifiers are improved, current-feedback design. Specifications are: sensitivity, 0.1 v per cm; input impedance (each lead to ground), 5 megohm; frequency response, flat to 20 cps, down 2 db at 50 cps for all amplitudes to 4 cm, peak to peak. Re-

cording is true rectangular and chart speeds are adjustable in nine steps from 0.25 to 100 mm per second. **Sanborn Co.**, Industrial Div., 195 Massachusetts Ave., Cambridge 39, Mass.

—Circle ITEM 491

Oscilloscope

has high sensitivity and large-screen display



Large-screen display of low-order inputs is provided by this oscilloscope, which is available with either a 17-in. or 21-in. rectangular tube. Sensitivity is 10 mv, peak-to-peak for full-scale deflection; linearity is 1 per cent; calibrated time base is adjustable from 10 microsec per inch to 1 sec per inch. The oscilloscope has a low drift rate and excellent long-term stability. Performance is not affected by line voltage changes. **Electromec Inc.**, Oscilloscope Dept., 5121 Fernando Road, Los Angeles 39, Calif.

—Circle ITEM 492

Strain Gage

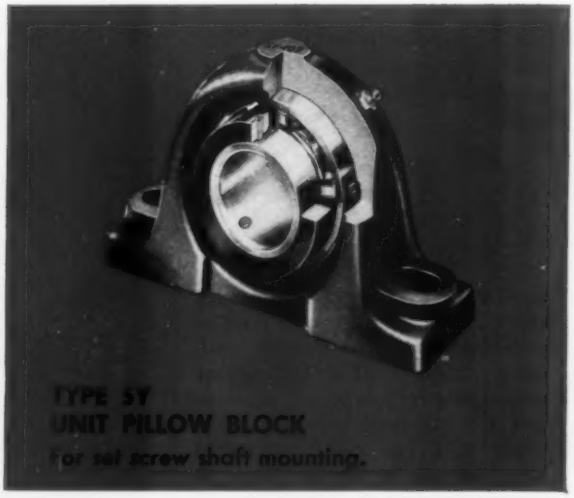
has metal-foil element for high current capacity

Bonded resistance-type strain gage consists of 0.0005-in. thick copper-nickel foil grid on an epoxy resin backing. Active grid dimensions are 1 x 11/32-in. and mounting dimensions are 1½ x ½-in. Supplied on a no-guarantee basis, the gages are packaged in kits of twenty, including cement, working tools, and instructions. Nominal resistance is 119 to 121 ohms and gage factor is approximately 2.20. Advantages of foil-type gage are: high heat dissipation and current capacity, flexibility for mounting on contoured surfaces, absence of fatigue-promoting discontinuities, and variety of patterns. **Baldwin-Lima-Hamilton Corp.**, Philadelphia 42, Pa.

—Circle ITEM 493

Most Positive Bearing For Dirt Exclusion and

now – a complete line of unit pillow blocks



Designers!

HERE'S HOW SKF HELPS MAKE YOUR PRODUCT BETTER

In offices throughout the U.S.A., SKF maintains the bearing industry's most experienced sales engineering staff. If bearings are part of your product, call the nearest SKF District Office for any engineering assistance you may need.

Operating Men!

LOOK FOR THE SIGN OF YOUR AUTHORIZED SKF DISTRIBUTOR

It is your guarantee of complete stocks and unbiased engineering assistance because only your SKF distributor stocks all types of bearings—ball, roller, spherical and tapered roller. You'll find his name in the classified telephone directory.

BALL BEARINGS CYLINDRICAL ROLLER BEARINGS SPHERICAL ROLLER BEARINGS

Seal Ever Devised Lubricant Retention...

...fully interchangeable with other makes

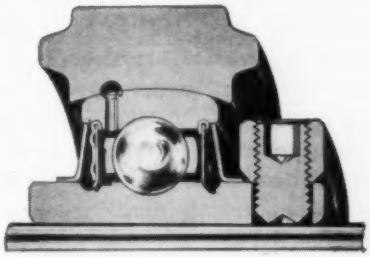
SKF UNIT PILLOW BLOCK FEATURES

- Long inner ring distributes load over great shaft area.
- The spherical outer ring of the bearing compensates for initial misalignment.
- Interchangeable with existing bolt-hole spacing and center height.
- Grease fitting in housing for relubrication of bearing.
- Bearing is easily replaced.
- Bearing is pre-lubricated and sealed at SKF—it's ready for operation.
- All housings are cast in one-piece for durability.

Special Features

Shown on the right is SKF's Bearing Seal Design which is the most effective ever developed. The seal itself, made of a specially designed metal backing plate and a Du Pont Fairprene washer, is staked into the bearing outer ring and makes *light* but *positive* contact with a groove in the bearing inner ring—a contact seal that acts as a relief valve and *can't pop out* when lubricant is added. This Red Seal is augmented by a rotating flinger—together they provide positive dirt exclusion and lubricant retention. 7781

SKF RED SEAL



SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of **SKF** *and* HESS-BRIGHT® *bearings.*

SUBSIDIARY

TYSON BEARING CORPORATION, MASSILLON, OHIO
—manufacturers of Tyson *tapered roller bearings.*

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BEARINGS AND PILLOW BLOCKS

Tyson TAPERED ROLLER BEARINGS

—ITEM 657—
For More Information Circle Item Number on Yellow Card—page 19

Professional Viewpoint

OUR February 9 editorial (Page 79) contained an oblique reference to engineers "escaping" into sales. Here, by an engineer, are some things that can and should be said

In Defense of Salesmen

Your editorial "The Freedom to Choose," presents vividly a number of provocative thoughts on the problem of engineering manpower in the United States compared with that in Soviet Russia.

The problem of assuring an adequate engineering personnel in the United States is a difficult one and certainly deserves more consideration than it is now being accorded. However, I would like to take exception to a remark which may convey the wrong impression. You state:

> Since there are no salesmen in Russia we can also be sure that no Soviet engineers are being lost to their profession through that avenue, as so many are in this country.

I feel this has unfortunate implications. A competent engineer can contribute effectively as a salesman, as a design engineer, as a construction engineer, or as an engineer in charge of operations.

Your very magazine is witness to the great contribution made by salesmen and sales organizations in exchanging ideas from one area to the other—in bringing the advanced thinking of the group creating ideas to the group requiring those creations. Our American system has been fruitful because of the ability to exchange ideas freely and, in no small measure, advertising and selling have contributed to this process.

I know there are times when those of us engaged in design or production feel that we would like to have some of the fellows who join the sales group stay on our side of the fence. However, we are relying on the salesmen to work

design data

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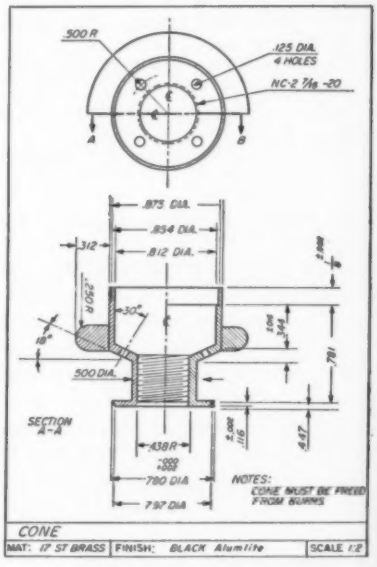
Professional Viewpoint

with us in translating abstract ideas to practical items, or are asking the sales engineers to bring our new developments to all possible users. In so doing, we eliminate the need for an overreaching bureaucracy to try to find the paths from creator to user.

DAVID ARONSON
Consulting Engineer
Worthington Corp., Harrison, N. J.

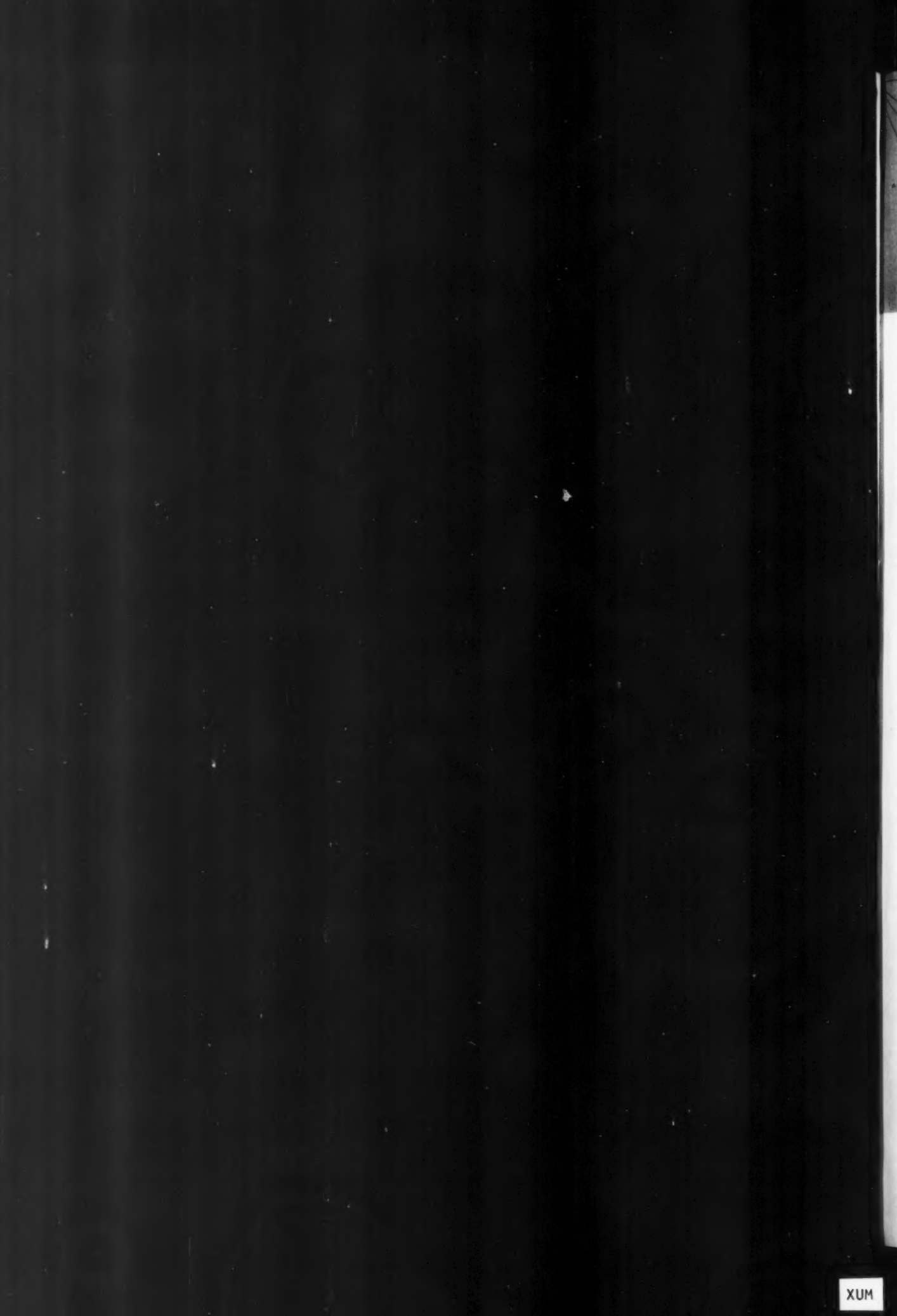
Can You Read A Drawing?

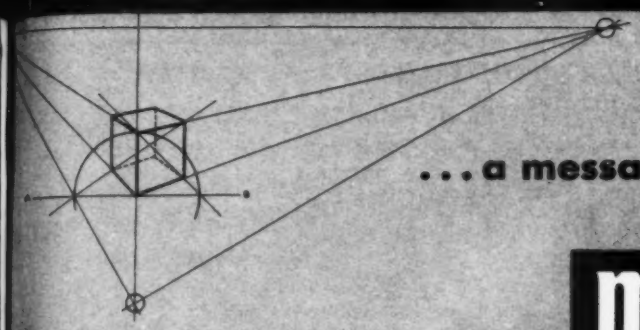
HOW many errors can you find in the drawing shown? If you're sharp, you may be able to find over 90 mistakes. The drawing is used as a quiz by Aircraft Radio Corp., Boonton, N. J., and is furnished through the courtesy



of Howard Cobb, chief of drafting department. Max Hoberman, consulting engineer, who sent the drawing, says that 93 errors are the maximum so far discovered by designers and draftsmen who have taken the test.

"Criticism comes easier than craftsmanship."—ZEUXIS.





...a message from the editors of

MACHINE DESIGN

Why We Believe You Will Benefit From Attending the First Design Engineering Show and Design Engineering Conference in Convention Hall, Philadelphia, May 14-17, 1956

Mass communication of ideas day in and day out is largely dependent on the two-dimensional printed page.

Technical and professional journals, like our own, provide at once an open forum for the interchange of engineering ideas and experience, and a market place where manufacturers can display their wares in front of the engineers who may need them to complete their designs.

Once in a while design engineers can get together in meetings sponsored by the professional societies. Such affairs can be likened to the editorial pages of a magazine come to life — where authors talk with their readers face to face instead of through the written word.

But what of the extensive new product-announcement and advertising pages? The obvious live counterpart of those sections of a magazine is the trade show or exposition. Here, very little has been done to cater to the specific interests of design engineers — until this year.

The Design Engineering Show is the first of its kind. Here, you — our readers — may expect to see in three dimensions many materials and components which you may have seen hitherto only as pictures or drawings in our advertising or announcement pages. Moreover, you will be able to meet and discuss with manufacturers' own people the products displayed.

In addition to the Show, you are invited to attend the concurrent Design Engineering Conference sponsored by the Machine Design Division of the American Society of Mechanical Engineers. The program will cover a broad range of subjects having current practical interest to design engineers. Presentations will be by panel discussions with audience participation.

The Design Engineering Show has the support of more than 170 leading manufacturers of materials and engineered components who have taken exhibit space. The Conference is being planned with the active participation of the editors of MACHINE DESIGN, PRODUCT ENGINEERING, ELECTRICAL MANUFACTURING, and MATERIALS & METHODS.

It can be truly said that the Show and Conference are like a magazine in 3-D — with high fidelity sound and color for good measure. We invite you to come and participate.

FACTS TO HELP PLAN YOUR VISIT TO THE FIRST DESIGN ENGINEERING SHOW AND CONCURRENT ASME DESIGN ENGINEERING CONFERENCE, CONVENTION HALL, PHILADELPHIA, MAY 14-17, 1956

WHO SHOULD ATTEND ?

Engineers who are responsible for the research, design, testing and development of the new products, components, and machinery used in all the key industries, are invited to attend the Design Engineering Show and the ASME Machine Design Conference.

Engineers who function under the following titles are just a few of the large number who will find this show of particular interest: Product Design Engineer, Project Engineer, Development Engineer, Materials Engineer, Designer, Design Analytical Engineer, Component Engineer, Chemical Engineer, Methods Engineer, Metallurgist, Mechanical Design Engineer, Machine Design Engineer, Test Engineer, Research and Development Engineer, Hydraulic and Pneumatic Engineer, Administrative Engineer, Design Group Supervisor, Division Superintendent, Manager of Engineering, Manufacturing Engineering Supervisor, Vice-President in Charge of Engineering, Experimental and Research Engineer, Electrical Engineer, Consulting Engineer, Aeronautical Engineer, Director of Design, Cost Reduction Engineer, Machine Development Engineer, Mechanical Engineer, Research Project Engineer, Stress Analyst, Structural Engineer, Test Design Engineer.

The meeting of such a group of key men in the design field will not only permit a free discussion of many common problems, but will give the designer a greater perspective of the entire design function.

WHAT WILL BE EXHIBITED?

The products of more than 170 manufacturers in the following categories will be shown in Convention Hall, Philadelphia, May 14-17, 1956. These products will be available for examination, comparison, and testing. Some of these are:

ELECTRICAL COMPONENTS

such as actuators, connectors, dynamotors, generators, insulators, meters, motors, switches and relays, rectifiers, solenoids, thermostats, wire and components, thermocouples, strain gages, timing motors, etc.

MECHANICAL COMPONENTS

such as axles, bearings, clutches, conveyors, drives, governors, mountings, couplings, speed reducers, timers, wheels, vibration mountings, springs, gears, belts and chains, lubricating equipment, etc.

ENGINEERING MATERIALS
metallic and non-metallic

such as aluminum alloys, clad metals, beryllium alloys, gray iron, high alloy steels, metal powders, titanium, magnesium, bearing alloys, nickel alloys, etc.; carbon, ceramics, cork, glass, jewels, paper, plastics, silicones, rubber, wood, graphite, etc.

FASTENERS

such as clips, nuts, retaining rings, rivets, welding, adhesives, etc.

FINISHES AND COATINGS

such as anodized finishes, chemical colorings, lacquers, paints and varnishes, plated coatings, etc.

HYDRAULIC AND PNEUMATIC COMPONENTS

such as accumulators, boosters, controls, pumps, cylinders, hose and tubing, piping, valves, etc.

SHAPES AND FORMS

such as die castings, drop forgings, formed non-metallics; perforated materials, press forgings, sand castings, tubing, etc.

ACCESSORIES

such as computers; drafting instruments, machines, supplies; recorders; reproduction equipment; supersonic generators; transducers, etc.

FACTS TO HELP PLAN YOUR VISIT TO THE FIRST DESIGN ENGINEERING SHOW AND CONCURRENT ASME DESIGN ENGINEERING CONFERENCE, CONVENTION HALL, PHILADELPHIA, MAY 14-17, 1956

Concurrent Design Engineering Conference, Convention Hall, Philadelphia, May 14-17, 1956, sponsored by the Machine Design Division of the ASME invites engineers to study industry's problems.

The chief editors of the leading publications in the product design field, serving as the Papers Committee, have drafted the program for the 4-day meeting. The session on Cost Reduction in Product Design will be devoted to General Electric Company's Value Analysis program. Finding and Training Engineers will be a panel session consisting of three members, who will stress the need for attracting men to the design field. Another subject will show how various mechanical and economic considerations dictate materials choices. Problems of Miniaturization will cover military as well as civilian products. The Recognition and Reward for Invention session will be a discussion of the Westinghouse Patent Award System.

HOW TO REGISTER FOR THE DESIGN ENGINEERING SHOW

Place:	Convention Hall, Philadelphia
Dates:	May 14-17, 1956
Hours:	12:30 pm to 5:30 pm daily, Monday through Thursday
Registration:	Registration for the show is FREE. Rapid Registration Tickets (to be filled out in advance to save time) can be obtained by writing to the Show Management:

Clapp & Poliak, Inc.
341 Madison Avenue
New York 17, New York

Request as many tickets for yourself and colleagues as you wish.

HOW TO REGISTER FOR THE DESIGN ENGINEERING CONFERENCE

Place:	Convention Hall, Philadelphia
Dates:	May 14-17, 1956
Hours:	9:30 am to 12:30 pm daily, Monday through Thursday
Registration:	Registration fee: $5 for ASME members, $10 for non-members, including a copy of Conference Proceedings. Register on arrival.

HOTELS

Write directly to the hotel of your choice in Philadelphia. Please be sure to specify the name of the person who will occupy room, date of arrival and probable departure. Mention the Design Engineering Show.

...a message from the editors of **MACHINE DESIGN**

THE FOLLOWING MANUFACTURERS WILL EXHIBIT THEIR ENGINEERED PRODUCTS AT THE First Design Engineering Show, Convention Hall, Philadelphia, May 14-17, 1956. QUALIFIED ENGINEERS WILL BE ON HAND TO SUPPLY INFORMATION ON THE LATEST DEVELOPMENTS. WE RECOMMEND YOUR ATTENDANCE.

Acme Steel Company
Air Maze Corporation
Alemite Division, Stewart-Warner Corporation
The Louis Allis Co.
Alloy Metal Wire Division
Aluminum Company of America
American Nickeloid Company
American Society of Mechanical Engineers
Amos Molded Plastics
Armstrong Cork Company
The Auburn Manufacturing Company

Bakelite Company, A Division of Union Carbide and Carbon Corporation
Balsa Ecuador Lumber Corporation
Bart Laboratories Division, Bart Manufacturing Corporation
Beemer Engineering Company
The Bellows Company
Boston Gear Works
Burndy Engineering Company, Inc.

Camloc Fastener Corporation
Cast Optics Corporation
Central Foundry Division, General Motors Corporation
Cerro de Pasco Corporation
Chicago Allis Mfg. Co.
Cleveland Cap Screw Co.
Coating Products
Colonial Alloys Company
Conolite Division, Continental Can Company, Inc.
Controlex Corporation of America
Coors Porcelain Company
Corning Glass Works
Cullman Wheel Co.
The Cuno Engineering Corporation
Curtiss-Wright Corporation, Metals Processing Division

The Franklin Dales Company
Detroit Controls Corp.
Diehl Manufacturing Company
The Dixon Corp.
The Dobeckmun Company
Doehler-Jarvis Division, National Lead Company
E. I. du Pont de Nemours & Co., Inc.
Durakool Inc.—Herma Seal Co. Inc.
Durametallic Corporation
Dynamic Gear Co., Inc.

Eaton Manufacturing Company, Reliance Division
Elastic Stop Nut Corporation of America
Electrical Manufacturing
Electro-Devices Inc.
Electroflex Heat Inc.
Ellis Associates
Encyclopaedia Britannica
Engineered Nylon Products, Inc.
Eriez Manufacturing Company

Falstrom Company
Ferguson Machine & Tool Co.
Flexible Tubing Corporation
Foote Bros. Gear & Machine Corporation

Formsprag Company
Frenchtown Porcelain Company
Fromson Orban Co., Inc.

The Garlock Packing Company
General Electric Company
General Findings & Supply Co.
The General Fireproofing Co.
The Glastic Corporation
The Globe Company, Grip-Strut Division
Gries Industries, Inc.
Gries Reproducer Corp.
Groov-Pin Corporation

Heim Company
Heli-Coil Corporation
Hermes Plastics Inc.
E. F. Houghton & Co.
Howard Industries, Inc.
Hunter Spring Company

The Improved Seamless Wire Company
Industrial Design Magazine
Industrial Equipment News
Instrument Specialties Company, Inc.
International Balsa Corporation
International Packings Corp.

Kennametal Inc.
Kimberly-Clark Corporation

L & L Manufacturing Company
L. O. F. Glass Fibers Company
The Lamson & Sessions Co.
The Lancaster Lens Company
La Salle Steel Co.
Leach & Garner
Lehigh Chemical Company
Lignum-Vitae Products Corporation
Linde Air Products Co., A Division of Union Carbide and Carbon Corporation
Linemaster Switch Corporation
Lovejoy Flexible Coupling Co.

Machinery Magazine
MacLean-Fogg Lock Nut Co.
Magnaflux Corporation
Mallory Sharon Titanium Corp.
Manheim Manufacturing & Belting Company
Marquette Metal Products Division, Curtiss-Wright Corporation
Materials & Methods
Mechanical Industries Production Company
Merkle-Korff Gear Co.
Micro-Balancing Inc.
Micro Switch Division of Minneapolis-Honeywell Regulator Co.
Minnesota Mining & Mfg. Co. Adhesives & Coatings Division
Multiple Extrusions Inc.
Mycalex Corporation of America

National Vulcanized Fibre Co.
Nelson Stud Welding, Division of Gregory Industries Inc.
Newark Wire cloth Company

New Hermes Engraving Machine Corporation
North Shore Nameplate Inc.

O'Sullivan Rubber Corporation

The Penton Publishing Company
Pic Design Corp.
The Polymer Corporation of Penna
Post Machinery Company, Electronic Products Division
Potter & Brumfield
Product Engineering
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Stromberg-Carlson Company A Division of General Dynamics Corporation
Sweet's Catalog Service
Sylvania Electric Products Inc.

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Thomas Publishing Company
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Thriftmaster Products Corporation
Tinnerman Products, Inc.
Titeflex, Inc.
Toyad Corporation
Tuttle & Kift, Inc.

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U. S. Royalite Division of United States Rubber Co.
U. S. Stoneware Company

Veeder-Root Incorporated

Wagner Electric Corporation
Warner Electric Brake & Clutch Co
The Weatherhead Company
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Whitney Chain Company
Wolverine Tube Division, Calumet & Hecla Inc.

The Yale & Towne Manufacturing Company, Powdered Metal Products Div.

as of Feb. 28, 1956

THE DESIGN ENGINEERING SHOW

CONVENTION HALL, PHILADELPHIA

MAY 14-17, 1956

THE ENGINEER'S

Library

Recent Books

Mechanism. *By Joseph Stiles Briggs; 418 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$6.50 postpaid.*

This book is an advanced text of kinematics, a reference on the analysis of mechanisms and a source of mechanical movements. Initial chapters demonstrate the application of vector equations to three dimensional motion. Subsequent chapters concern gears, cams, rotary drives, linkages, tension and flexural links, compression links, computing mechanisms, and the control of mechanisms. Separate chapters cover special topics, the Newtonian mechanics of rigid bodies, and a repertory of mechanism.

•

Hydraulic and Pneumatic Power for Production. *By Harry L. Stewart, assisted by Floyd D. Jefferis; 416 pages, 6 by 9 inches, clothbound; published by The Industrial Press, 93 Worth St., New York 13, N. Y.; available from* MACHINE DESIGN, *$8.50 postpaid.*

Subjects covered in this reference book include the types of fluid power equipment currently available, hydraulic and pneumatic circuits for performing various functions, control circuits and safety devices. Also, separate chapters cover packing and seals; air filters, lubricators and regulators; and combinations of fluids in a single system.

•

Handbook of Fastening and Joining of Metal Parts. *By Vallory H. Laughner and Augustus D. Hargan; 622 pages, 8½ by 11 inches, clothbound; published by McGraw-Hill*

The Engineer's Library

Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from MACHINE DESIGN, *$15.00 postpaid.*

This book is a compilation of standards, performance data, and methods to aid in the selection of fasteners for metal parts and products.

Directed to designers and production men, the book covers joining of dissimilar metals, the types of resins and adhesives, and the advantages and disadvantages of different types of joints. It also covers screw threads, nuts and bolts, collars, couplings, keys, brazing, soldering, and types of welding.

Introduction to Electronic Analogue Computers. *By C. A. A. Wass;* 237 *pages,* 5½ *by* 8½ *inches, clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, *$6.50 postpaid.*

This book is a report on the present status of analog computing. It covers both theory and design of differential analyzers, simulators and their components. The mathematical problem statements are given for a variety of systems which can be solved with an analog computer. These are discussed by means of idealized computing networks. Detailed treatment of computing components includes discussion of their limitations. The computer setups for solving a number of specific problems are presented and several existing computers are described.

New Standards

Engineering Standards, Multiple V-Belt Drives. *24 pages, 8½ by 11 inches, paperbound; published by Multiple V-Belt Drive & Mechanical Power Transmission Association, 27 East Monroe St., Chicago 3, Ill., and The Rubber Manufacturers Association, 444 Madison Ave., New York 22, N. Y.; available from either association, $1.00 per copy.*

This standard supersedes an earlier edition dated Jan. 1951. Basic changes in the revised man-

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The Engineer's Library

ual include ten pages of new horsepower ratings. These, in general, are increased ratings for standard quality belts. Also, the ratings for premium quality belts are included for the first time. The range of belt speeds covered is from 200 to 6000 fpm.

♦

System for Straight Bevel Gears, ASA B6.13-1955, AGMA 208.01. 9 *pages, 8½ by 11 inches, paperbound; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.00 per copy.*

This system covers recommended tooth proportions and dimensions of blanks for generated straight bevel gears. The 1955 standard supersedes the revision of 1940. Changes in the 1955 revision concern clearance and whole depth of fine-pitch teeth, proportional tooth thickness of pinion and gear, and adoption of 20-degree pressure angle instead of 14½-degree. Information regarding angular gears has been added.

♦

Scheme for the Identification of Piping Systems, ASA A13.1-1956. 7 *pages, 8½ by 11 inches, paperbound; published by and available from the American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.00 per copy.*

This standard describes a systematic plan for identifying the contents of industrial piping systems primarily by stenciled legends and secondarily by color.

Association Publications

Proceedings of the Ninth Annual Conference on the Administration of Research. 108 *pages, 8½ by 11 inches; published by and available from New York University Press, Washington Square, New York 3, N. Y., $4.00 per copy.*

This book is a verbatim report of a three-day meeting held at NYU. Participants were directors and other executives of industrial, university, and govern-

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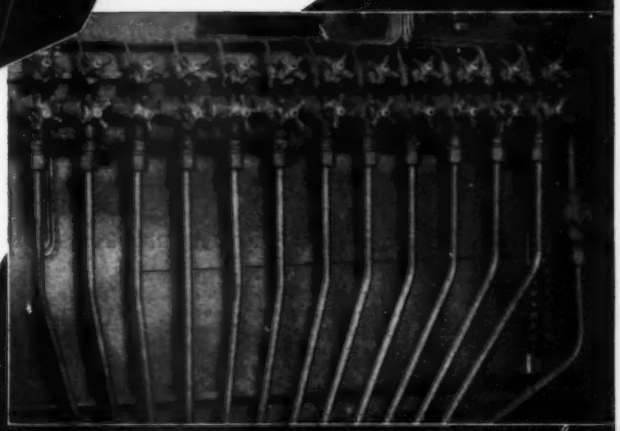

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—ITEM 664—

The Engineer's Library

ment research laboratories.

In 24 talks the following subjects are covered: appraising and rewarding the researcher's output, management in the research laboratory, communication problems in a research operation, physical facilities for research, and basic research in an applied research laboratory. Informal floor discussions that followed the talks are also reported.

•

Design Manual for Roller and Silent Chain Drives. *95 pages, 8½ by 11 inches, clothbound; published by Association of Roller and Silent Chain Manufacturers; available from Mr. A. L. Taylor, executive secretary of the association, P.O. Box 5398, Indianapolis, Ind., $3.50 per copy.*

This manual describes the theoretical and practical engineering principles involved in the application of chain drives. It was prepared mainly for student engineers and is intended to be useful to practicing engineers and purchasing agents. Chapters cover the history of the chain drive; a comparison of mechanical power drives; description and design of chains and sprockets; design, installation, lubrication and maintenance of roller chain; and silent chain drives.

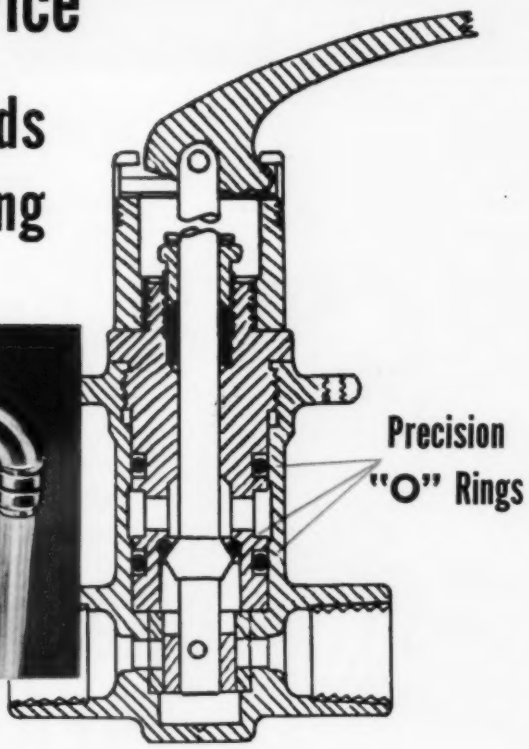
Manufacturers' Publications

Design Handbook for Stainless Steel. *40 pages, 8½ by 11 inches, paperbound; published by and available from Alloy Metal Wire Div., H. K. Porter Co. Inc., Prospect Park, Pa.*

This handbook was planned to help design engineers select the right stainless steel for their products. Chapters are devoted to the properties of various grades of stainless steel. The subjects are: corrosion resistance, heat resistance, mechanical properties, electrical and magnetic properties, spring properties and workability. Other chapters concern heat treating, cleaning, machining, welding and soldering.

New Faucet with Precision "O" Rings gives longer service

...ends dripping

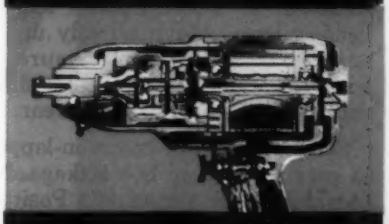


The Gyro Brass Manufacturing Corporation water faucet has no washers, spindles or seats to replace or renew. With the aid of Precision "O" Rings, a single motion controls both water volume and temperature. Dripping is eliminated. Endurance tests indicate ring life of over 15 years of normal service.

For Gyro Brass Manufacturing Corporation, and for hundreds of other manufacturers, the use of Precision "O" Rings means dependable long life service. They are compression molded—rigidly inspected—meet all military and commercial specifications—the finest made! At Precision, you'll find "O" rings in sizes and compounds to meet your requirements.

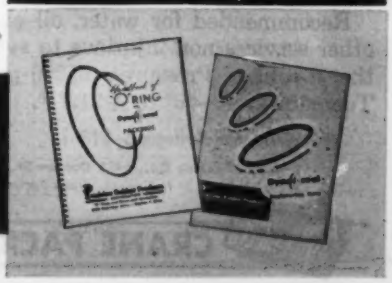
What is your sealing problem? There is an expert—the Precision engineer—ready to help you in product design and "O" ring specifications. You can rely on him—and on Precision, the world's largest exclusive producer of "O" Rings.

Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.



In air-powered impact wrench 14 floating "O" rings help achieve compactness, result in reduced break-out friction and lower running friction.

Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals



Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Dept. 9, Oakridge Drive, Dayton 7, Ohio

Canadian Plant at:
Ste. Thérèse de Blainville, Québec

—ITEM 667—

New Machines

Materials Handling

Hopper Feeder: Feeding unit receives parts in bulk and discharges them, aligned and oriented, to another machine at any position. The feeder does not jam. It can deliver parts in a wide range of sizes and shapes to machines involved in a variety of processes. Accessory equipment available includes an overhead conveyor to elevate discharged parts and deliver them up to 50 ft away, and a gage to reject parts that do not meet specified tolerances. *Cargill Detroit Corp., Birmingham, Mich.*

Sheet Feeder: Automatic machine is designed to feed a single sheet of steel to a press. It can handle up to 30 sheets per minute, depending upon blank size. Blanks from 8 in. diam to sheets 48 x 144 in. are accommodated. The unit is self-contained and movable. Its controls can be interlocked with those of the presses. *Hamilton Automation Inc., Hamilton, O.*

Lift Truck: Warehouser high-lift platform electric standup truck is designed for skid-handling operations in narrow aisles. It has a capacity of 4000 lb and is 68 in. high. Platform height is adjustable from 6 to 96 in. from the floor. *Yale & Towne Mfg. Co., Yale Materials Handling Div., Philadelphia.*

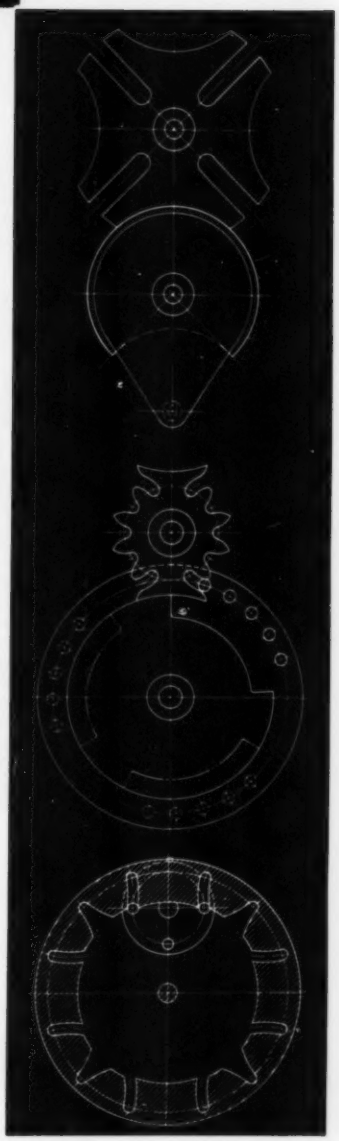
Metalworking

Drilling Machine: Vertical universal - joint - drive hydraulic - feed machines are available in three basic models: VHU-12, with 12-in. way width, 16-in. stroke and 7½ hp; VHU-18, with 18-in. way width, 18-in. stroke and 15 hp; and VHU-24, with 24-in. ways, 24-in. stroke and 20 hp. Each basic model is built with a variety of head sizes and spindle-drive arrangements. Spindle speeds are varied by means of a speed selector and pick-off gears in the main gear box. Each spindle-drive is equipped with an independent high and low speed

again available in reprint • • • •

"MECHANISMS FOR INTERMITTENT MOTION"

by Otto Lichtwitz



A SYSTEMATIC TREATMENT OF THE PROBLEMS INVOLVED FOR IMPARTING INTERMITTENT MOTION THROUGH EXTERNAL AND INTERNAL GENEVA AND STAR WHEELS, AND INTERMITTENT MECHANISMS FOR INTERSECTING AND CROSSING SHAFTS

In the December 1951, and January, February and March 1952 Issues, MACHINE DESIGN published what has proved to be an enormously successful series of articles on "Mechanisms for Intermittent Motion". Mr. Lichtwitz' approach to the subject of intermittent motion is systematic and extremely well organized. The tables provided to reduce time and effort in making detailed calculations are themselves invaluable.

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change. Hydraulic power unit is driven by a separate motor. The machine conforms to JIC electric and hydraulic standards. Ways are hardened and ground steel; all parts are lubricated automatically. *Buhr Machine Tool Co., Ann Arbor, Mich.*

Straightener and Polisher: Model 2FX unit straightens and polishes a wide variety of grades of cold drawn bars with diameters from ¾ to 4½ in. at a speed of 300 fpm. On the horizontal pass line two large rolls are opposed by three smaller rolls. Four of the rolls are driven to provide correct burnishing action to finish the bars as they are being straightened. Concentricity is controlled by the machine. Size tolerance can be controlled by raising or lowering the diameter of the bar, depending on the analysis of the grade being straightened. Power is provided by a 60/70 hp, 400/1600 rpm, 230 v, adjustable-speed dc motor, top-mounted to conserve floor space. *Sutton Engineering Co., Pittsburgh.*

Surface Grinders: Large-capacity units provide automatic pushbutton depth feed of 0.00004-in. and cross feed of 0.0002-in. after hand adjustment. Grinding capacity range in the five models available is from 14 x 18 in. to 14 x 48 in. Each model has a 5-hp, two-speed motor mounted on the spindle and adjustable tapered bearings in the spindle. Table and saddle are mounted on ball bearing assemblies operating on hardened and ground ways. Wheels up to 4 in. wide can be used in conjunction with a cross feed up to 2½ in. per stroke. Machines are also available with completely automatic grinding, the machine stopping itself after three idle runs. *Aaron Machinery Co. Inc., New York.*

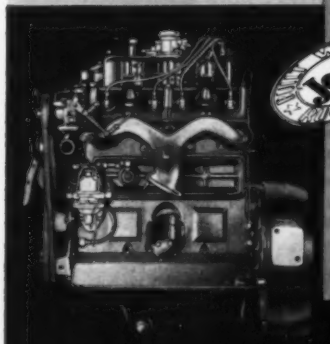
Deep-Throat Presses: Styleline Series C presses perform blanking, forming, drawing, perforating and combination die and automatic feeding operations. Available in eight models with capacities from 22 to 150 tons, each with several throat depths, the machines incorporate a front-to-back crankshaft design which permits the use of a wide slide and long gibbing. All gearing is enclosed within the press

412 lb. 'Jeep' engine

Jockeys 78,000 lb. railroad cars

'Jeep'-powered Whiting Trackmobile moves railroad cars, with loaded weight of 39 tons, to dumper. 'Jeep' Industrial Engine supplies high torque needed in this vehicle on track or when moving on rubber tires from job to job, road or unpaved ground.

There's power to spare in 'Jeep' Industrial Engines, whether you're moving railroad cars carrying multi-ton loads or doing any of a thousand back-breaking jobs. And this power is developed in a rugged engine only two feet long! Its high efficiency stems from such "proven-in-action" features as positive crankcase ventilation to avoid oil-thinning, acid-forming condensates; positive valve rotators for longer, more even valve wear; proven combination of piston T-slots and heat dams — and more. Installed directly into your equipment or employed in 'Jeep' Power Units, 'Jeep' Industrial Engines develop dependable, economical power that lasts. Write today for technical information.



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☐ 'Jeep' Industrial Engines ☐ 'Jeep' Power Units

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Firm .....

Address .....

City ..... Zone ..... State .....

'Jeep' Power Giant Industrial Engines

WILLYS MOTORS, INC. Toledo, Ohio

—ITEM 671—

For More Information Circle Item Number on Yellow Card—page 19

New Machines

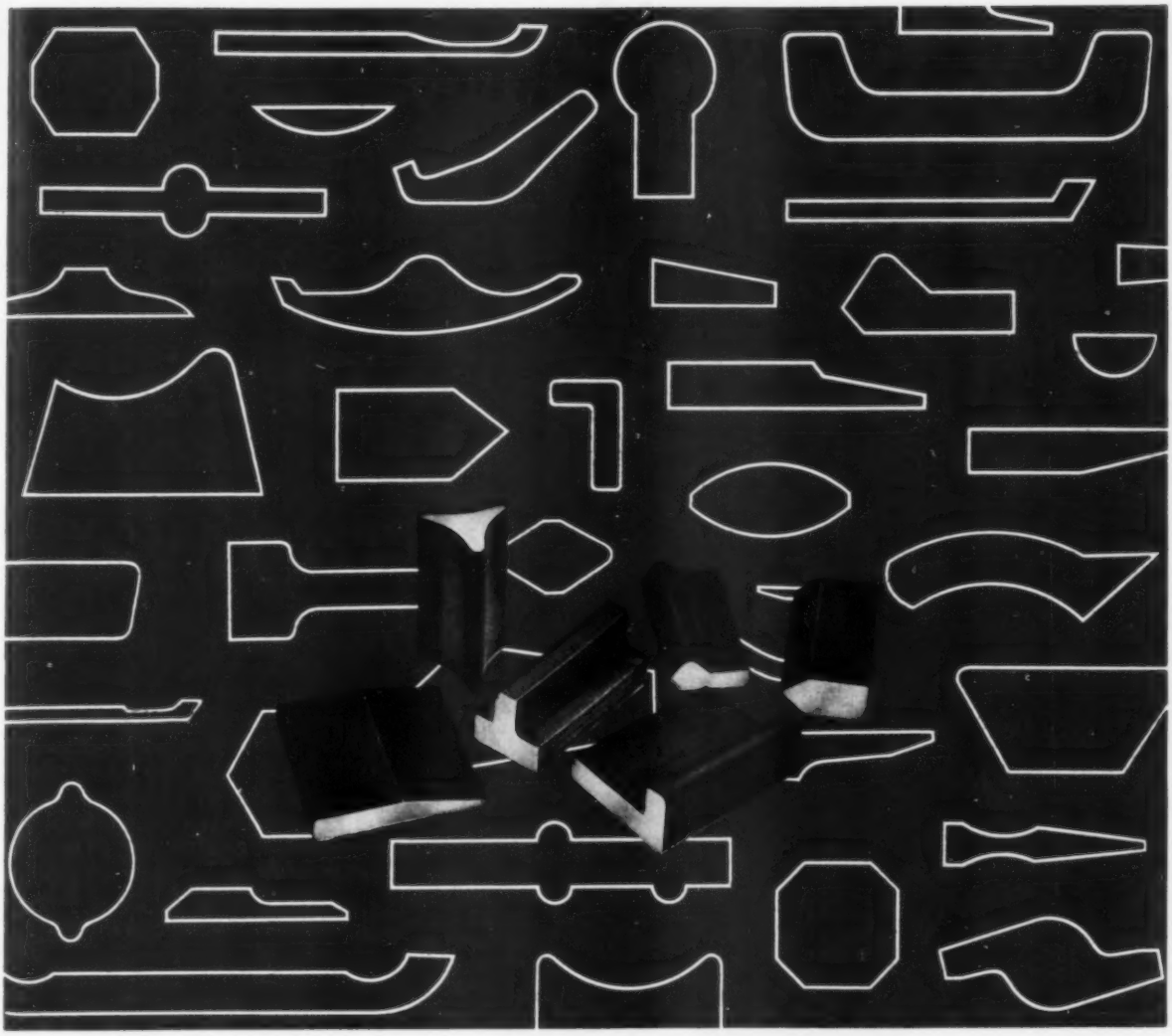
frame to minimize shaft deflection. Frames are box type with a heavy crown and deep bed. Geared models are equipped with electropneumatic clutch and air-releasing brake. Nongeared models have a mechanical sleeve clutch and drag brake, and are also available with pneumatic clutch trip and air-releasing brake for use with automatic feeds. *Niagara Machine & Tool Works, Buffalo.*

Die Caster: Cold-chamber, 800-ton machine produces aluminum parts weighing up to 35 lb, such as automotive grills, transmission housings, motor blocks and outboard motor castings. Positive, self-compensating mechanical link-wedge locks the clamp to the rated tonnage. Pushbutton control, equipped with safety interlock, provides central screw daylight and tonnage adjustment. The operator controls strokes, slowdowns and automatic cycling, including three-core pull and ejector sequence. Flexible injection stroke provides close control of metal volume and accommodates variations in cover die thickness. High-pressure hydraulic elements are manifolded. Heavy die platens are 59 x 55 in. Die height is variable from 34 to 16 in. Power input is 80 hp. *Hydraulic Press Mfg. Co., Mt. Gilead, O.*

Portable Tools

Utility Hammer: No. 15 air-operated portable hammer is designed for use as a rock drill or cement-chipping tool. An external cam lever control permits rapid change from rotating to straight hammering action. The tool cuts clean, round holes to 1⅝ in. diam. Exhaust air blows chips out for fast drilling. Two models are available for use as wet and dry tools. Overall length is 17¼ in.; weight, 15 lb. *Thor Power Tool Co., Aurora, Ill.*

Nut-Running Tool: Air-operated torque control Impactool impacts nuts to a preset torque for precision tightness. When resistance is equal to stress preset in the torsion bar, the impact mechanism rebounds and automatically shuts the unit off. The tool requires a two-man bolting team. The torque setting remains constant until the



Crucible special shapes

for better special steel parts at lower cost . . .

If you're machining intricate sections from solid bars—or using expensive forgings—stop! Choose instead, a *Crucible special shape* that approximates the finished part. *Crucible special shapes* eliminate rough-machining operations . . . reduce scrap losses.

There's practically no limit to the *special shapes* available at Crucible, in a wide variety of special steels. Rolls for over 400 special shapes are available—other shapes can be rolled to your specifications. Your local Crucible representative can give you the whole story of how *special shapes* can cut costs—save time. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

New Machines

adjustment is changed. Operation is reversible with full power in either direction. Size 5340T tool has an adjustable torque range to 550 lb-ft and average working speed of 635 rpm. Impacts per minute average 1270. The unit will run ¾ and ⅞-in. high-strength bolts. *Ingersoll-Rand Co., Air Tool Div., New York.*

Testing and Inspection

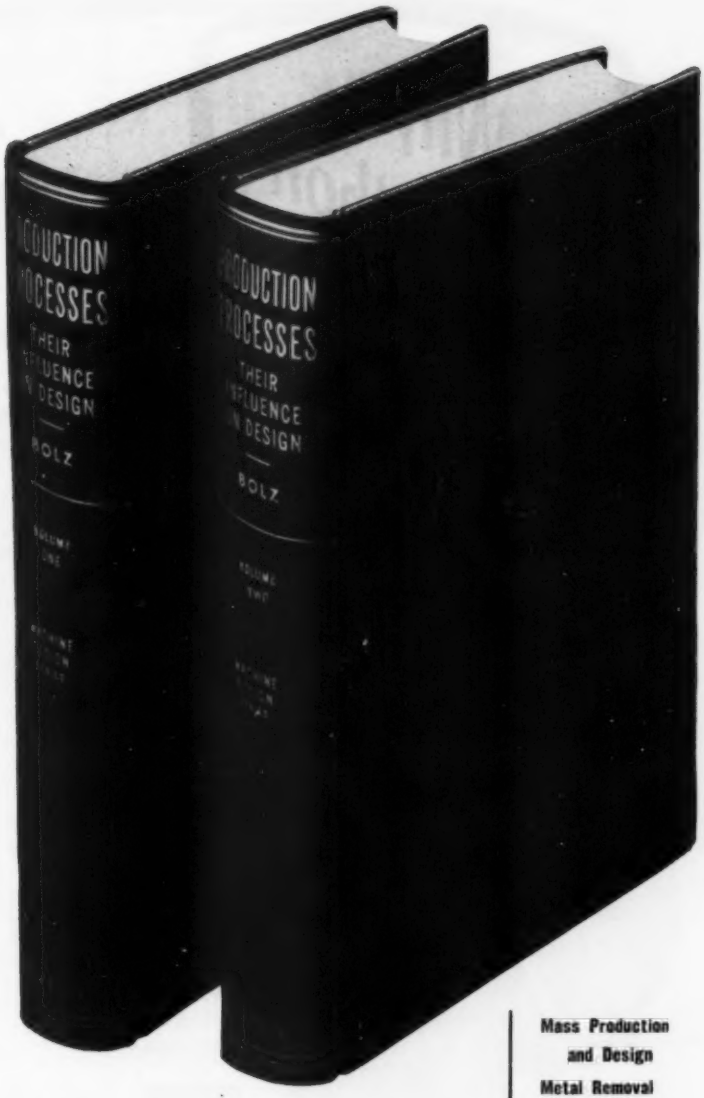
Creep Testing Machine: Testing unit with a capacity of 20,000 lb performs four basic types of creep tests: Long-time tests, creep-rupture tests, relaxation and constant strain rate tests. The machine has lever arm loading and load measurement. Motor-driven loading screw keeps the levers in balance during creep of the test specimen. Tubular 16-in. furnace provides for tests up to 1800 F. It is equipped with thermocouple for heat measurement and control. A protective device within the furnace prevents burnouts. Elongation is indicated in increments of 0.000025-in. Accuracy of the loading systems is within 1 per cent of applied load or 0.2 per cent of capacity, whichever is greater. *Baldwin - Lima - Hamilton Corp., Philadelphia.*

Brinell Hardness Tester: Model L bench model machine is designed for laboratory and shop use. A motor-operated hydraulic unit, the tester has a long stroke to eliminate anvil height adjustments and load accuracy is within ASTM standards. The Brinell load is adjustable by turning a screw. Load is applied by depressing a lever on the side of the machine. Releasing the lever instantly releases the load. Brinell ball penetrator has a ¾-in. stroke. Throat depth is 6 in. The unit occupies an area of 9 x 25 in. *Steel City Testing Machines Inc., Detroit.*

Hardness Tester: Mark VI Penetrascope tests ferrous and nonferrous metals in a wide range of sizes, shapes and contours in laboratory and production lines. It can handle specimens ranging from 0.002-in. thick to cylinders over 8 ft diam. Measurement can be made within a tolerance of 1 mu or 0.000040-in. *Tinius Olsen Testing Machine Co., Willow Grove, Pa.*

Real Dollar & Cents

"HOW-TO" for LOW COST Production



PRODUCTION PROCESSES

THEIR INFLUENCE ON DESIGN

With the emphasis today so pointedly on cost reduction, and with production methods always so important a part of the cost picture, this "shop approach" to design can be your guide to lower costs while products are still in the drawing-board stage. In effect, these two usable encyclopedias of practical information bring production know-how right into the engineering room.

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- **924 pages of fully illustrated text**
- **Covers 56 different processes**
- **Includes 9 major production areas**

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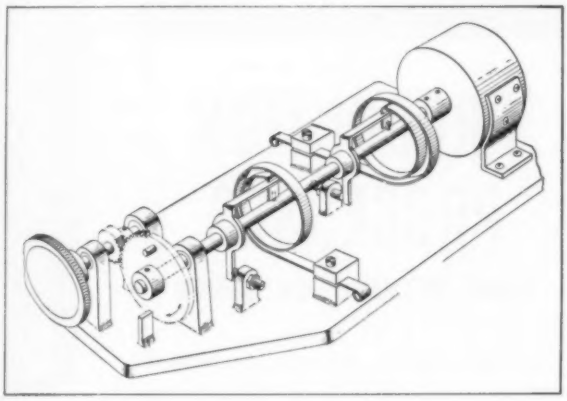
NOTEWORTHY Patents

Shaft Positioning Mechanism

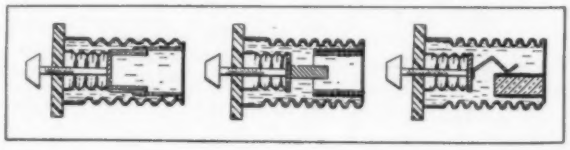
Accurate repositioning of instrument shafts to zero or neutral position after rotation is accomplished automatically by using two oppositely-wound spiral springs in conjunction with adjustable stops. As the shaft is deflected off center, a pin fixed to the shaft "winds up" one of the spiral springs. When the shaft is released, the spring rotates the shaft back to the neutral position, stopping at a point determined by the adjustable stop. Deflecting the shaft in the opposite direction winds up the other spring in



the same manner. A second adjustable stop determines the neutral point for the second spring. Both stops are normally adjusted to provide the same neutral or zero setting for return from either direction of rotation. *Patent* 2,714,000 *assigned to Bell Telephone Laboratories Inc. by T. J. O'Connor and C. H. Williams.*

Sealed Electrical Control System

Coaxial bellows are utilized to provide a movable electrical control element within a hermetically-sealed, fluid-filled enclosure. An adjustable inner bellows is attached to the controlled element within the fixed outer bellows. The stationary element, which might be the plates of a capacitor or the resistance winding of a potentiometer, is

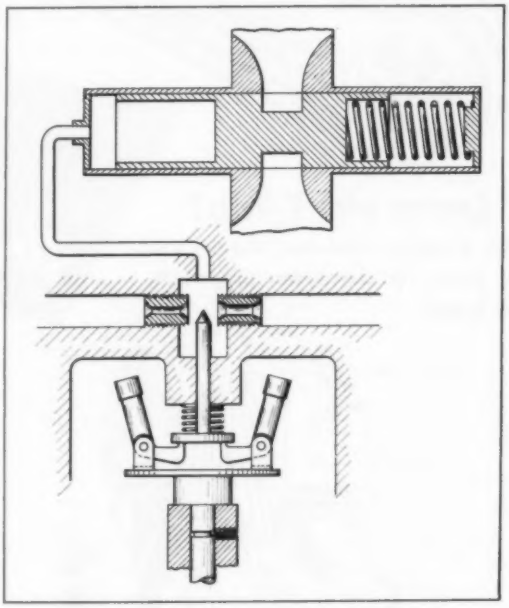


Noteworthy Patents

mounted to the outer bellows. Temperature rise, affecting the fluid volume within the container, merely causes the outer bellows to expand. Rupture due to internal pressure is thus prevented. Also, as the inner bellows is adjusted, the outer bellows automatically compensates for corresponding changes in volume within the enclosure. *Patent 2,714,184 assigned to Sprague Electric Co. by D. B. Peck.*

Pressure Control Valve

Hydraulic flow to a servo device is controlled by a sensitive feedback-type valve. Changing the position of a needle in the flow path deflects varying amounts of fluid into an auxiliary, calibrated pressure cylinder. Fluid pressure within the cylinder actuates a movable piston which serves as



an input metering valve. As the needle valve is actuated to vary pressure in the cylinder, the piston regulates the metering passage openings to maintain constant pressure output. The device may be adapted to convert a small mechanical motion into a differential hydraulic pressure. *Patent 2,713,869 assigned to Bendix Aviation Corp. by C. O. Weisenbach.*

Antifriction-Bearing Seal

Frictional drag between a rotating rubber seal around a bearing race and a stationary retaining ring is minimized by utilizing centrifugal force to reduce contact pressure between the two elements. When the shaft is not rotating, the elasticity of the conical shaped molded rubber seal acts to hold it in contact with the retaining ring to prevent leakage of the lubricant. When the shaft rotates,

New ASCO 3-Way Solenoid Valve assures MILLIONS OF TROUBLE-FREE OPERATIONS

NO EQUAL IN SIMPLICITY!

Simplicity is the secret of this remarkable, new 3-way diaphragm valve. It has *only three operating parts.* Compare this with the larger number of parts found in conventional 3-ways! That's one reason why the new ASCO valve means trouble-free operation . . . substantial savings in maintenance costs . . . reduction in down-time losses.

The EXTRA HEAVY FORGED BRASS BODY houses only three moving parts: Two diaphragms and a core. Corrosion protection is assured. All parts in contact with fluids or gases are brass, stainless steel or Buna-N.

SIMPLICITY IN OPERATION

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Exceptionally large flow capacity makes rapid recycling feasible . . . cylinders fill and vent rapidly . . . valve operates up to 400 cycles per minute over millions of strokes.

CONVERTS IN 30 SECONDS

Developed for dependable control of liquids and gases, the valve can be converted from normally open to normally closed or the reverse by simple rotation of the valve bonnet.

This new valve is absolutely tight seating . . . no closely fitted parts or valve seat grinding required. Available now in ⅜" and ½" pipe sizes, both with full-⅜" orifices, it can be mounted in any position.

WRITE NOW for your copy of ASCO Bulletin 8316, or have the ASCO Engineer call.

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DEPENDABLE CONTROL

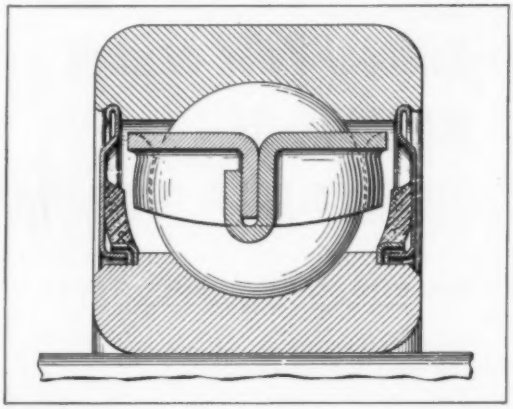
Automatic Switch Co. • 387 LAKESIDE AVENUE • ORANGE, NEW JERSEY

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

—ITEM 679—

Noteworthy Patents

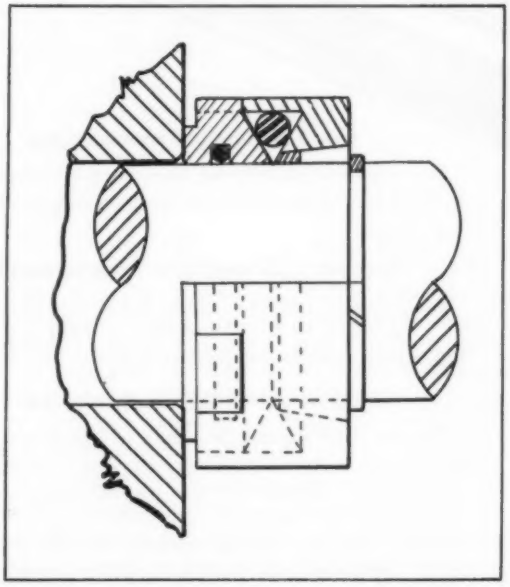
centrifugal force causes the rubber seal to pull away from the stationary surface, reducing contact pressure. Lubricant is also thrown away from



the sealing surfaces during shaft rotation, further reducing the possibility of leakage. *Patent* 2,714,-022 *assigned to Ahlberg Bearing Co. by Charles Nelson Jr.*

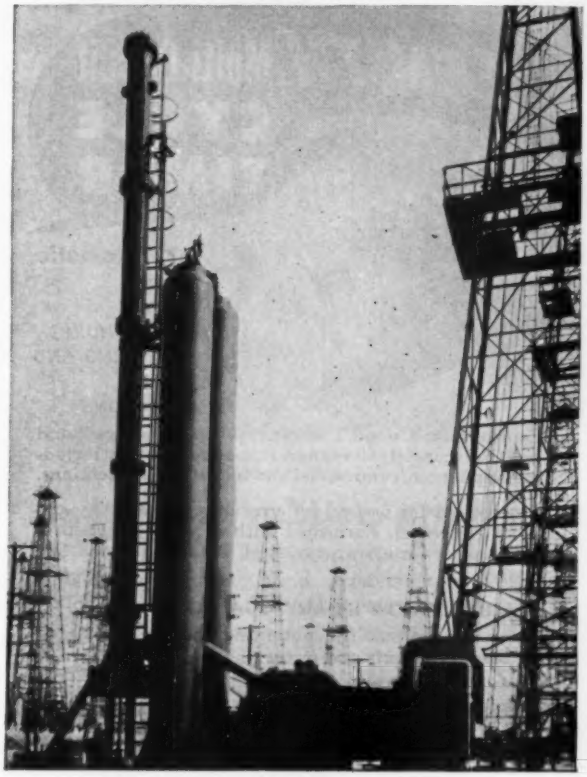
Shaft Seal

A large O-ring placed between interlocking metal collars actuates a seal assembly to provide fluidtight sealing between a rotating shaft and a housing. As the shaft and seal assembly rotate, centrifugal force tends to flatten the O-ring, forcing the collars to

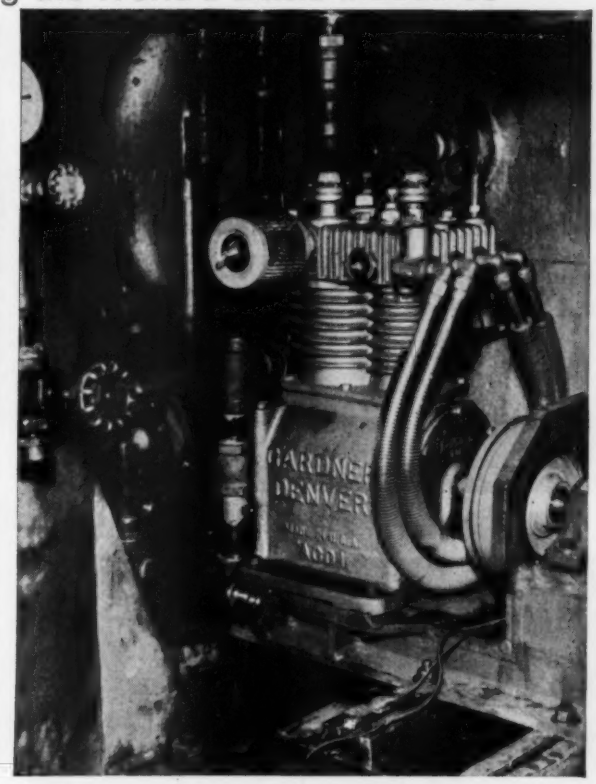


move apart axially. Wedge shaped surfaces of the collars increase the sealing pressure, permitting the assembly to maintain sealing under a wide range of pressures. *Patent* 2,714,025 *assigned to* ***Metal Seal & Products Inc. by A. H. Heinrich.***

Gardner-Denver . . . Serving the World's Basic Industries



Lufkin oil well pumping unit.



Gardner-Denver Model ADD Compressor. Standard on all Lufkin hydraulic pumping units.

How Gardner-Denver works for design engineers...

in oil well pumping, for example

PROBLEM: In developing this hydraulic oil well pumping unit, Lufkin engineers had a fluctuating pumping load problem.

ANSWER: The answer was found in a dependable Gardner-Denver compressor delivering air when needed to twin surge tanks which constantly and automatically counterbalance the pumping load. Significantly, Gardner-Denver compressors are standard equipment.

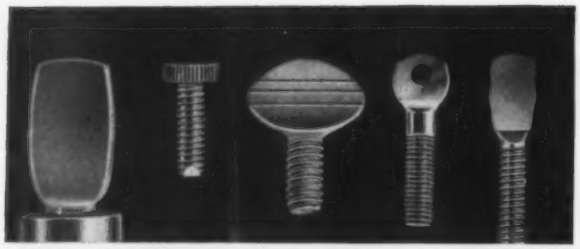
Gardner-Denver compressors, pumps and air motors are designed into many machines serving all industry. Gardner-Denver service is worldwide. Our engineering department will gladly discuss possibilities of applying standard Gardner-Denver units or special designs, if required.

GARDNER - DENVER

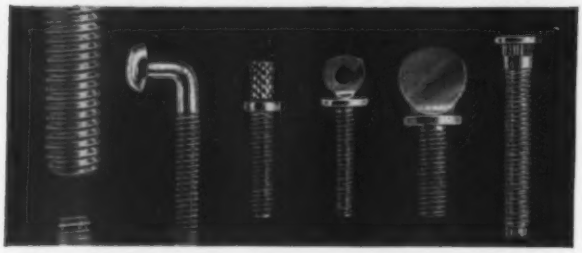
THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

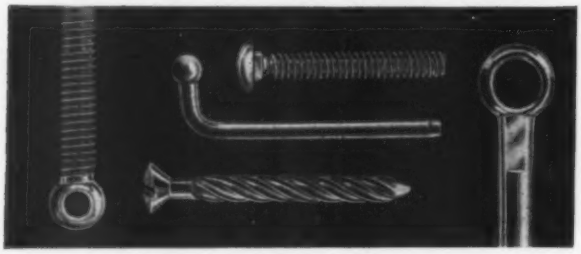
—ITEM 681—



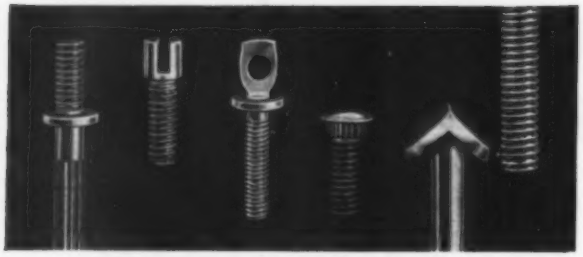
YOU CAN'T BEAT COLD FORMING



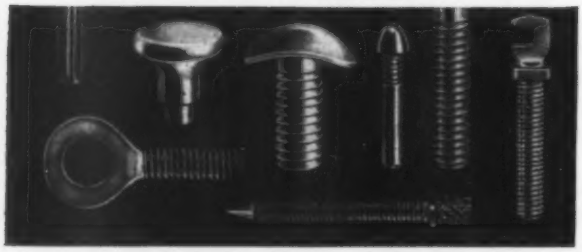
FOR PARTS LIKE THESE—AND



YOU CAN'T BEAT PROGRESSIVE



FOR COLD FORMING . . .



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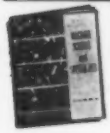

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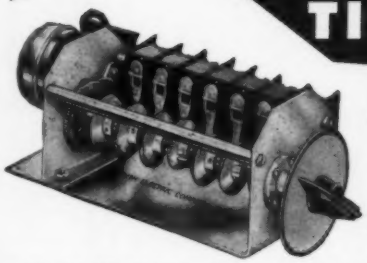
THE PROGRESSIVE MANUFACTURING COMPANY

DIVISION OF THE TORRINGTON COMPANY
52 Norwood St., Torrington, Conn.

—ITEM 682—

LONG LASTING! ACCURATE!

ZENITH Multi-Circuit CYCLE TIMER



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TIMING
MIXING
COMPOUNDING
PROCESSING AND
SIMILAR
OPERATIONS

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Can be set for on and off periods with as many circuits as desired. Furnished with or without synchronous motor for elevator control, limit switch and like operations.

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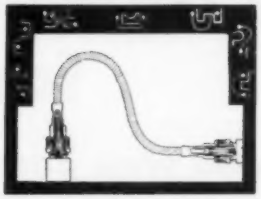
See classified telephone directory for name of local distributor.

ZENITH ELECTRIC CO.

149 W WALTON ST. • CHICAGO 10, ILL.

—ITEM 683—

SIMPLIFIED TRANSMISSION OF POWER



It was only a few years ago that transmitting power around a corner or over an obstacle required the use of universal joints, bevel gears, or gear trains. This gearing was not only very expensive, but it also consumed much needed space, causing a headache for the design engineer, the production department, and those who had to service the finished product. Today it is possible to realize the maximum space available through the utilization of flexible shafting which eliminates all gearing efficiently and economically. You may do this because flexible shafting transmits power over, under, and around all obstacles while operating under a very high torque. In the illustration you will notice how much more direct and simpler is the flexible shaft. You will notice too that complicated alignment is unnecessary because of the high flexibility of the flexible shaft assemblies. There are very few moving parts to a flexible shaft assembly which does away with vibration and offers long life.

For complete information on how flexible shafting can be applied to your product or plant, write on your letterhead to the F. W. Stewart Corporation, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

—ITEM 684—

For More Information Circle Item Number on Yellow Card—page 19

Industrial rubber products designed to cut your costs

Through every manufacturing step, Cooper research, development and production engineers work as a team, produce as a team, are available as a team to solve your rubber parts problems. Every job gets personal attention. Every job is a challenge to produce precision parts at the lowest possible unit cost. Cooper facilities are the most modern. Cooper delivery schedules are consistently met. Write for your free copy of the "Cooper Story". Learn how Cooper saves time and money for rubber parts users like yourself. Get the facts — no obligation, of course.

Cooper

Send inquiries to INDUSTRIAL RUBBER PRODUCTS DIVISION

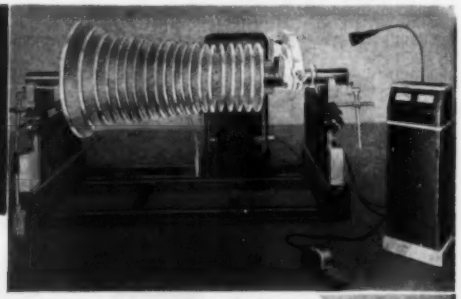
Cooper Tire & Rubber Company, Findlay, Ohio

—ITEM 685—

---

4 OUT OF 5

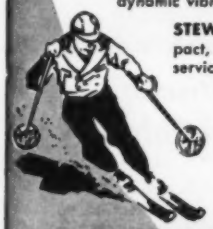
VIBRATION PROBLEMS ORIGINATE WITH UNBALANCE



NOW Save up to 50%* of your balancer investment ... Eliminate Dynamic and Kinetic unbalance ... with a STEWART-WARNER ELECTRONIC INDUSTRIAL BALANCER

IN PRODUCTION... greatly reduce your manufacturing costs by eliminating rejects caused by rotor unbalance.

FOR MAINTENANCE... reduce your maintenance expense by eliminating down time situations requiring replacement of bearings and shafts, labor, etc., in addition to production loss. Instrumentation will also measure aero-dynamic vibration factors.



STEWART-WARNER electronic industrial balancers are sturdy, compact, extremely accurate and engineered for years of trouble-free service.

Extreme maximum and minimum ranges are engineered into every STEWART-WARNER ELECTRONIC INDUSTRIAL BALANCER. Other makes require more than one machine to attain these capacities.

Stewart-Warner Electronic Industrial Balancers are manufactured and distributed by:

CRADLE and PORTABLE MODELS available

Check These Stewart-Warner Established Capacities:

- ½ lb. to 25,000 lb. weight range
- ½" to over 96" diametral capacity
- .03 in.-oz. Dynamic sensitivity
- Convenient friction belt drive requires no adaptors and eliminates belt wrap-around problems
- Less than 2 minutes set-up time without supervision
- From $3795 including operator training
- 4½" to over 144" length range
- .01 in.-oz. Kinetic sensitivity
- Operating safeguards

The above capacities are established. Should your requirements exceed the above, please write us stating your exact balancing problem.

*No other industrial balancer incorporates so many advanced features, yet the Stewart-Warner sells at approximately 50% less than other advertised industrial balancers.

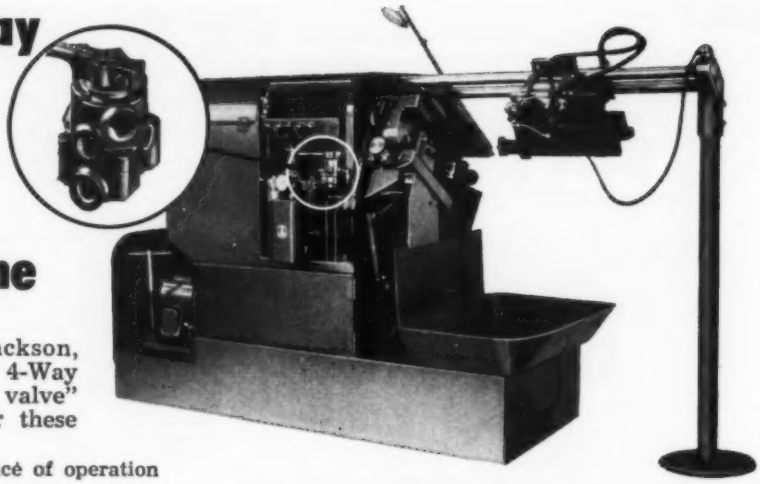
MERRILL *engineering laboratories*

Write now for FREE brochures with complete information

"Industrial Electronic Balance Specialists since 1935" • DEPT SJ • 1240 LINCOLN STREET • DENVER 3, COLORADO

—ITEM 686—

NOPAK Dual 4-Way is Main Air Control on "Modern" Cutting-Off Machine



Modern Machine Tool Co., Jackson, Mich., uses the NOPAK Dual 4-Way valve as the "main air control valve" on its Cutting-Off Machine for these reasons:—

1. It provides the necessary sequence of operation control.
2. It is "easily mounted . . . in readily accessible position".
3. It directs air pressure either to part of the air system, or the whole system, as required.
4. With valve lever at 45°, "the operator can set the tools, with a gauge, against the stock while it (the stock) is locked in the collet".
5. In normal running position with valve lever at 90°, air is directed to other parts of system, while maintaining pressure on collet cylinder during cutting cycle.

This application may suggest how you can use NOPAK Valves and Cylinders for effective control and application of fluid power in your product, or in your plant equipment. For other suggestions see the NOPAK Application Manual.

Write for Latest Shelf-Stock Listings

GALLAND-HENNING NOPAK DIVISION
2752 SOUTH 31ST STREET • MILWAUKEE 46, WISCONSIN

Representatives in Principal Cities

NOPAK
® VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

A 8574-½HA

—ITEM 687—

FREE!
96 PAGE Abart SPEED REDUCER Handbook

SPEED REDUCERS
...over 75 types and sizes—ratings from 1/50 to 168 hp.—ratios up to 10,000 to 1. Specials to order.

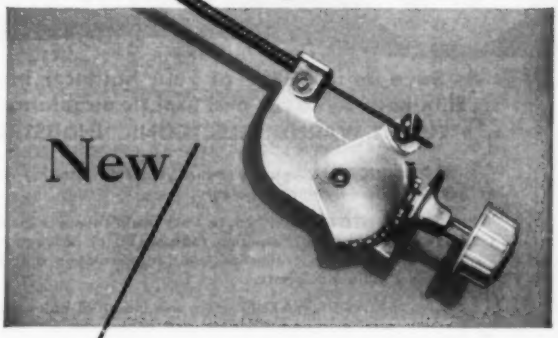
WRITE TODAY!

√ illustrations
√ diagrams
√ rating tables
√ descriptions
√ how to select

ABART GEAR and MACHINE CO.
Mfrs. of Gears and Speed Reducers
4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

—ITEM 688—

ARENS Compact Control



For Remote operation of Dampers, Vents and Valves

Easy to install, low cost sector gear and pinion device with wire flexible control. Converts rotary motion to linear push-pull. 1½" travel. Occupies only 1¾" x 1¼" panel area. Requires only one nut for mounting. Write for information.

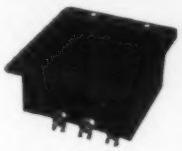
Write for Catalog
40 page illustrated Arens Remote Push-Pull Control Catalog. Write for it.

ARENS CONTROLS, INC.
2009 Greenleaf Street
Evanston, Illinois

—ITEM 689—

For HEAVY DUTY WORK!
Severest Electrical Services

P-506-CE—Plug with Cap



S-506-DB
Socket with deep Bracket

JONES PLUGS & SOCKETS
500 SERIES
Proven Quality!

For 5,000 Volts, 25 Amperes per Contact Alterable by circuit Characteristics.

Socket contacts of phosphor bronze, knife-switch type, cadmium plated. Plug contacts hard brass, cadmium plated. Made in 2, 4, 6, 8, 10 and 12 contacts. Plugs and sockets polarized. Long-leakage path from terminal, and terminal to ground. Caps and brackets, steel parkerized *(rust-proofed)*. Plug and socket blocks interchangeable in caps and brackets. Terminal connections most accessible. Cap insulated with canvas bakelite.

Write for Jones BULLETIN 20 for full details on line.

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP

—ITEM 690—

Canadian Aircraft Manufacturer Selects CADDY TOGGLE CLAMPS

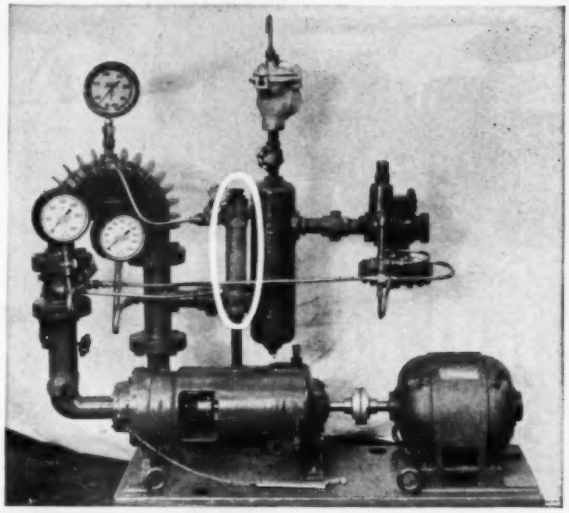
AVRO AIRCRAFT LTD. selected CADDY Toggle Clamps because of their long life and rugged construction. Fast action was the second claim. These same qualities are found in the planes built by AVRO.

Send for your FREE '56 Catalog today

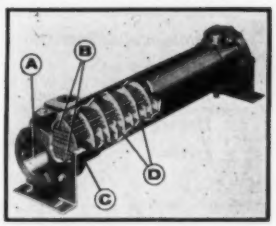
CADDY®
Erico Products, Inc.
2070 E. 61st Place • Cleveland 3, Ohio
IN CANADA: ERICO INCORPORATED, 3571 Dundas St., West, Toronto 9, Ontario

—ITEM 691—

Young Engineering Talent
Pays off for Cochrane



Young Coolers cut line losses in condensate return pump system



Young Type "F" Shell and Tube Heat Exchanger

THE PROBLEM: To eliminate line losses between process equipment and Cochrane Condensate Booster Drainage Control Units.

How Young solved it

Young Type "F" Heat Exchangers were specified to reduce water temperature 5 degrees before mixing it with incoming condensate at the mixing tube. Lowering the temperature of the fluid entering the mixing tube offsets line pressure losses . . . boosts pump efficiency.

A. Smooth flow bonnet distributes fluid with minimum turbulence.
B. Tubes are brazed into headers.
C. Gasket eliminates by-passing, fluid leakage.
D. Baffles made to close tolerance.

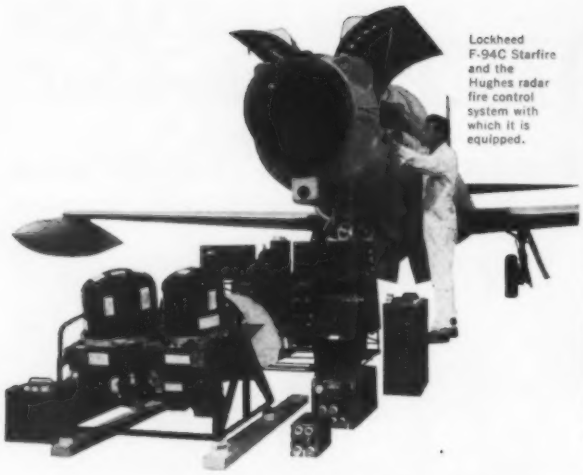
Write Dept. 306D for FREE Catalog

Put Young Talent to work for you . . .

Solving heat transfer problems is what we do best because it is our very reason for being. You, too, can harness the power of Young engineering talent. Write, wire or call without obligation.

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY
Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

—ITEM 692—



Lockheed F-94C Starfire and the Hughes radar fire control system with which it is equipped.

Hughes has been the leader from the beginning in applying electronic computers to airborne fire control equipment. Today every U.S. Air Force and Canadian continental defense interceptor uses Hughes-developed and Hughes-manufactured systems.

PRODUCT DESIGN at HUGHES

As the intercept problem becomes more and more automatic, additional equipment such as new-type computers, control surface tie-in (CSTI), autopilots, and other units must be integrated into the system. Faster speed and heavier engines dictate more streamlining–and hence less space for electronic gear. The result is even more miniaturization and compact packaging, evolved from special techniques.

This all means that now the product design engineer is more important than ever before. In the Product Design Laboratory he is a vital part of the formal link between the Research and Development activity and the optimum configuration and installation arrangements for the systems "black boxes."

Write to HUGHES *for information regarding positions open.*

SCIENTIFIC STAFF RELATIONS

HUGHES RESEARCH AND DEVELOPMENT LABORATORIES

CULVER CITY, LOS ANGELES COUNTY, CALIFORNIA

—ITEM 693—

push-pull CONTROLS

Compression & Tension Type

Aircraft cable is strung with spherical steel shells in a rigid or flexible housing sealed with "O" rings. 3" standard bend radius. ¾" minimum bend radius.

Three Types:

1. *Light Duty*—Compression Ult. Load 1250 lbs.; Ult. tension 960 lbs.
2. *Heavy Duty*—Compression Ult. Load 1650 lbs.; Ult. tension 960 lbs.
3. *Extra Heavy Duty*—Compression Ult. Load 3050 lbs.; Ult. tension 3900 lbs.

Modernize your push-pull control system with Southwest Mechanical Push-Pull Controls. Eliminate bell cranks, pulleys, and dual cables. Send for ENGINEERING MANUAL giving detailed prints and complete specifications covering materials, finishes, capacities. Please address Dept. MD-56.

SOUTHWEST PRODUCTS CO.
1705 So. Mountain Ave., Duarte (Los Angeles County), Calif.

—ITEM 694—

This Special Delivered in Less Than a Week!

It was a rush job! A manufacturer needed this special hinge fast. He came to Stanley . . . and he's glad he did. Our Industrial Hardware Division was able to make and deliver a substantial quantity in *less than a week!*

The Stanley Works has been making all kinds of products out of metal for over 100 years. We have experience, facilities and personnel to do many jobs well. Send us your problem. Write Industrial Hardware Division, The Stanley Works, 694 Lake St., New Britain, Conn., or the Indianapolis Office — 5165 N. Keystone Ave., Indianapolis 5, Ind.

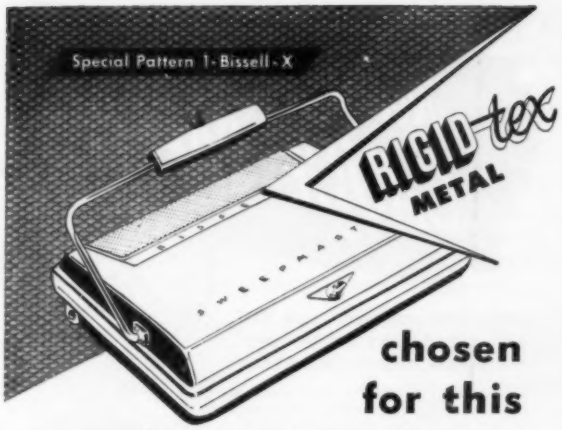
STANLEY

The Stanley Works, New Britain, Connecticut

Hardware • Tools • Electric Tools • Steel • Steel Strapping

—ITEM 695—

For More Information Circle Item Number on Yellow Card—page 19



chosen for this award winning design

RIGID-tex Metal adds a decorative touch to the modern styling of this sweeper, chosen to be displayed in the Good Design Exhibit, New York Museum of Modern Art.

Its mar-resistant beauty gives a product distinctive identity, taking it out of the "look-alike" class.

RIGID-tex Metal is produced in over 40 standard patterns, in any metal, finish or color. Exclusive patterns like that used above can also be developed.

See Sweet's Design File 1a/Ri or write us for information.

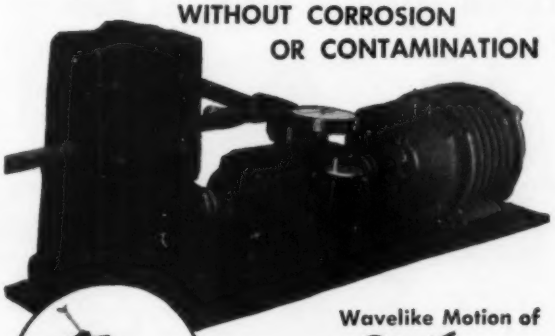
RIGIDIZED METALS CORP.
6934 OHIO STREET BUFFALO 2, N. Y.
Sales Representatives in Principal Cities

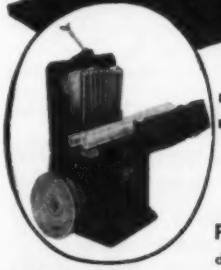
—ITEM 696—

PUMP

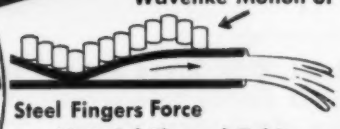
Liquids • Gases • Slurries

WITHOUT CORROSION OR CONTAMINATION





Wavelike Motion of



Steel Fingers Force Material Through Tubing

Prices range from.....$55 to $500 depending on size of pump and accessory equipment required.

Write for Catalog

SIGMAMOTOR Inc.
26 North Main Street • Middleport, N. Y.

—ITEM 697—

Here is how you can get Good Gears that will cost you Less!

You send the gear drawings and a request for prices on definite quantities.

We will engineer the drawing and the gears free, to determine the most economical gear to operate safely, efficiently and advantageously.

When we have made your gears, you will have received less expensive gears with completely detailed and designated information on the drawings of each gear that will enable you to buy the measured requirements anywhere, at the lowest prices.

GEAR RANGE

Straight and Coniflex Tooth Bevel Gears, 2" to 23", depending on ratio
Spur Gears, to 54" diameter
Helical Gears, to 54" diameter
Worm Gears, to 54" diameter
Worms to 12" diameter
Ground Thread Worms to 6" dia.
Herringbone Gears, to 36" dia.
Instrument Gears—1" dia. and up
Internal Gears—to 36" O.D.
Gear Grinding. Involute and square splines, ground and unground

Sier-Bath
PRECISION GEARS

Sier-Bath GEAR and PUMP CO., Inc.
Founded 1905 9237 Hudson Blvd., North Bergen, N. J. Member A.G.M.A.
Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings

—ITEM 698—

ROCKFORD

MEMO
Clutch must maintain it's torque

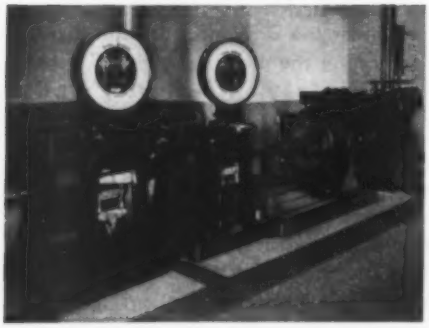
ROCKFORD CLUTCHES, of all types and sizes up to 18", are thoroughly tested for torque capacity — with this powerfull,

PULLMORE

OIL OR DRY

SINGLE OR DOUBLE

MULTIPLE-DISC



accurate Dynamometer. Arranged with an Automatic Cycling Device, this Dynamometer is also used for severe wear testing of facings, linkage, splines, etc. Let ROCKFORD engineers utilize our extensive clutch testing equipment to develop more efficient clutches for *your* products.

ROCKFORD
Clutch Division
BORG-WARNER
311 Catherine St., Rockford, Ill.

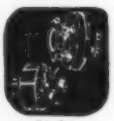
Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center



Light Over Center

Power Take-Offs

Speed Reducers

B. W. ENGINEERING MAKES IT WORK

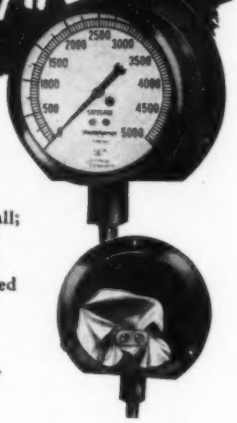
ENGINEERING B-W PRODUCTION

B. W. PRODUCTION MAKES IT AVAILABLE

CLUTCHES

—ITEM 699—

New advance in... GAUGE SAFETY



Another Marsh development... now "SAFE-CASE" gauge for those conditions where over-pressures of explosive force can occur.

Face well protected by solid metal wall; but, still more important, *entire back* is thin metal plate that opens out to exhaust any abnormal pressure. In testing, heavy blank cartridges, fired within back of case, did not even break crystal.

Use "Safecase" for your toughest services. It is standard in Marsh "Mastergauge"—the highest development in pressure gauges. Ask for facts.

MARSH INSTRUMENT CO.,
Sales affiliate of Jas. P. Marsh Corp.
Dept. B, Skokie, Ill.
HOUSTON BRANCH PLANT: 1122 Rothwell St. Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada

Test Proves Safety
Explosive force of cartridge merely opens out safety-release back. Back is firmly attached to case and cannot be dislodged during a pressure blow-out.

MARSH GAUGES

—ITEM 700—

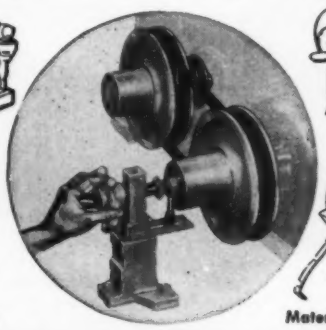
SPEED SELECTOR

VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines

Mowers and Tractors

Machine Tools



Special Equipment

Materials Handling

New! Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

CATALOG FREE! WRITE TODAY

SPEED SELECTOR INC.
120-B NOBLE COURT • CLEVELAND 13, OHIO

—ITEM 701—

WHAT IS THE PROPER AMOUNT OF TENSION TO APPLY TO A BELT?

Notwithstanding the many factors involved, it can be summed up in a few words as THE MINIMUM TENSION NECESSARY TO TRANSMIT THE REQUIRED POWER WITHOUT SLIPPAGE.

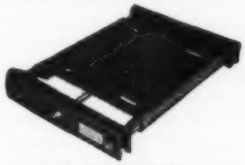
WHY THE MINIMUM?

Because more avails nothing, and EXCESSIVE STRESSES ON BELTS AND BEARINGS MATERIALLY SHORTENS THEIR LIFE.

The Proper Tension can be had, and maintenance reduced to a negligible quantity by mounting the motor on a Tension-Controlling AUTOMATIC BASE. Micromatic adjustment for the Proper Amount of Tension is made while operating under load, merely by turning a screw. Not a bolt or nut is disturbed. Nothing could be simpler, and there is nothing more accurate.

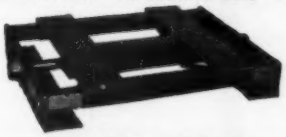
The AUTOMATIC BASE can be mounted in any position, and the motor pulley may rotate in either direction.

WHY NOT PROVIDE THE "MISSING LINK" BETWEEN THE MOTOR AND YOUR MACHINE BY USING AN AUTOMATIC BASE?



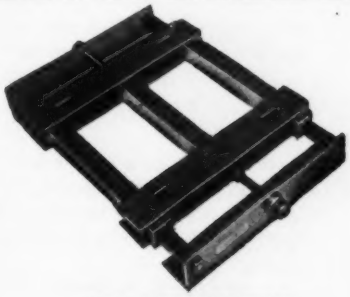
THE "SIMFLEX"

Provides Functional Utility at a Low Price. Made in two fractional sizes and for Old NEMA frames sizes 203 through 326.
Not recommended for use with motors having New NEMA frames.



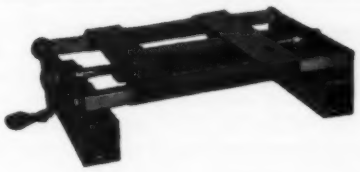
THE "SR" TYPE ST

A refined product made to close tolerances. The spring and working portion of the adjusting screw are enclosed and sealed in a grease-packed tube. The smooth walls of the motor carriage cooperate with close fitting square steel rails. Made in two fractional sizes, and for both Old and New NEMA frame sizes 182 through 326-U.



THE FLEXIBLE "BB"

The motor carriage rolls on linear ball bearings. All working parts are grease-packed and sealed. Stocked in four sizes for NEMA frames 364 through 505. Bases for larger motors, size unlimited, built to order.



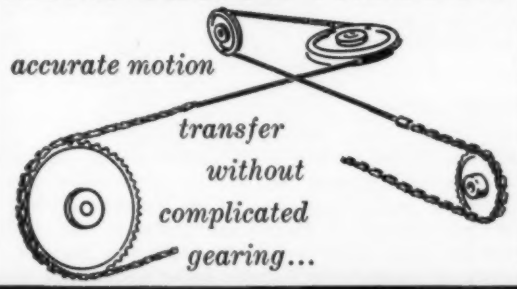
THE "SR" TYPE SQ

For motors equipped with Variable-Pitch pulleys. The BASE with 'finger-tip' control at the crank handle.
Made in two fractional sizes, and for both Old and New NEMA frame sizes 182 through 326-U.

AUTOMATIC MOTOR BASE CO.
WINDSOR, N. J.

—ITEM 702—

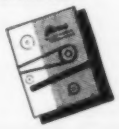
MORE DESIGN FREEDOM



SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

NEW CATALOG



Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

123 E. Montecito Avenue,
Sierra Madre, California

Sierra ENGINEERING CO.

T. M. REG.

—ITEM 703—

FREE... 64 PAGE CATALOG

WORLD'S LARGEST LINE OF WORK HOLDING EQUIPMENT— CHUCK JAW BLANKS, CAST ALUMINUM AND MALLEABLE KNOBS, WHEELS, HANDLES—PLUS HUNDREDS OF OTHER JIG AND FIXTURE COMPONENTS

COMPLETE DETAILED SPECIFICATIONS
ENGINEERING DRAWINGS • COST SAVING DATA
write for your copy—TODAY!

JERGENS TOOL SPECIALTY CO.
Dept. MD-4 712 E. 163rd St., Cleveland 10, Ohio

—ITEM 704—

ENGINEERS
AVAILABLE OR WANTED

WANTED: Mechanical Engineers and Mechanical Draftsmen. Growing company expanding Engineering Division. Opportunity for rapid advancement into management and development work on mechanical parking garages, aircraft hangars, industrial buildings, TV broadcast antenna towers. Liberal benefits including retirement. Moving expenses paid. Write: E. L. Smith, Dresser-Ideco Company, One of the Dresser Industries, 875 Michigan Avenue, Columbus 8, Ohio.

WANTED: Advertising Man for Technical Products: Previous advertising experience not necessary but helpful. Must have at least two or three years of college with courses in engineering and technical subjects and like to write. If you have the qualifications we have an opportunity open for you. Man selected will be trained in all phases of industrial advertising. In your letter of application state age, education, positions held, and give statement of why you want a career in advertising. Location: well-known Connecticut company. Address Box 894, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Engineers—New Product Development. Ingenuity and initiative applied to New Product Development with a growing far sighted company means progress for the experienced Electrical or Mechanical Engineers who are selected for these choice positions. Experience required in: Mechanical Design, Heat Transfer, Servo Mechanisms, Stress Analysis, Electro-Mechanical Devices. These positions offer an opportunity to grow in the fields of Atomic Power and Automation. Reliance Electric and Engineering Company, 1088 Ivanhoe Road, Cleveland 10, Ohio. Glenville 1-3530, Extension 570.

WANTED: Design Engineer—Aluminum Product Development. To assist Chief Design Engineer in offering technical assistance and design service all branches of industry. Position requires exceptional design ingenuity, imagination, flexibility and offers stimulating combination of diversified design activities and personal contact with leaders in industry. Please send resume to: Director of Engineering Services, Reynolds Metals Company, 2500 S. Third St., Louisville, Kentucky.

ENGINEERS
Electronic *Mechanical*

There's room to...

GROW
AT MELPAR

Currently we seek men with experience in one or more of the following:

- Network Theory
- Systems Evaluations
- Microwave Technique
- UHF, VHF, or SHF Receivers
- Analog Computers
- Magnetic Tape Handling
- Digital Computers
- Radar and Countermeasures
- Packaging Electronic Equipment
- Pulse Circuitry
- Microwave Filters
- Flight Simulators
- Servomechanisms
- Subminiaturization
- Electro-Mechanical Design
- Small Mechanisms
- Quality Control and Test Engineers

More and more these days you hear top engineers talk about the many growth opportunities at Melpar. With an increasing number of significant electronic projects, an enlarged staff and facilities, Melpar provides many opportunities for professional growth and advancement. Our new laboratory is an engineer's dream come true; a building conceived by and constructed for the ENGINEER – 265,000 sq. ft. of complete engineering facilities.

We are located in Fairfax County of northern Virginia where housing is reasonable and plentiful—whether you desire a private home or an apartment. Although we are in a truly suburban atmosphere, we are only 10 miles from the nation's capital with all its recreational and social advantages. Here you and your family can grow in an environment to match your professional growth.

Send resume to Technical Personnel Representative,

melpar, inc.
A subsidiary of the Westinghouse Air Brake Co.
3000 Arlington Blvd., Dept. MD-19, Falls Church, Va.
11 Galen Street, Watertown, Mass. • 99 First St., Cambridge, Mass.

—ITEM 706—

to help you solve your spring design problems

"MECHANICAL SPRINGS"

by A. M. Wahl

THOROUGH DISCUSSION OF FUNDAMENTAL PRINCIPLES . . . PRACTICAL FORMULAS FOR DESIGN . . . AUTHORITATIVE INFORMATION ON SPRING APPLICATIONS . . . IN 435 PAGES FULLY ILLUSTRATED WITH DETAILED DRAWINGS.

Thousands of design engineers have discovered "MECHANICAL SPRINGS" by A. M. Wahl . . . it has become a practical aid to spring design in hundreds of design libraries.

It contains the kind of information that enables preliminary calculations to be made on the design of all types of springs: helical, disk, Belleville, flat, leaf, torsion, spiral and volute.

And no matter what your problem . . . working stress . . . fatigue . . . buckling . . . or just plain maximum efficiency, you will find that "MECHANICAL SPRINGS" can reduce the "guesswork" as well as save you time and materials.

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Penton Publishing Co.
Penton Building
Cleveland 13, Ohio

Send me____copies of "MECHANICAL SPRINGS" at $6.00 per copy.
☐ Remittance enclosed in which case book will be sent postpaid
☐ Please bill me ☐ C. O. D.

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE ____ STATE _____
(Add 3% to orders for delivery in Ohio to cover State Sales Tax.)

MECHANICAL DESIGN ENGINEERS
Salary up to
$9,000.00
IN MILITARY ELECTRONICS
at

S-C

Stromberg-Carlson
newest division of
General Dynamics Corp.

We are seeking engineers with a minimum of three years experience. It is desired that you have been engaged on military electronics projects in a design capacity, although similar experience may well qualify you.

Equipment will range from small airborne receivers to complete radar systems.

Your responsibilities will include:

- combining the basic electronics circuitry developed by our electrical engineers into a mechanical structure designed to meet military environmental conditions
- design of common mechanisms, gear trains and mechanical devices which the structure or circuitry requires
- original design of unique mechanical and electromechanical devices which are singular to this type of equipment

You will be located in Rochester, New York, a medium sized city, with unlimited recreational and cultural attractions — find out for yourself!

Send letter or resume to:

R. W. Holmes
Electronics Engineering Dept.
Stromberg-Carlson
100 Carlson Rd.
Rochester 3, N. Y.

—ITEM 707—

three typical

"12 POINTER"

APPLICATIONS

where wrench clearance was the deciding factor...

ALUMINUM MARSDEN
ATOMIC ENGINEERING
APPLICATION

HI-CARBON SPECIAL
AUTOMOBILE ENGINE
APPLICATION

STEEL "HUGLOCK"
ELECTRIC EQUIPMENT
APPLICATION

The "12 POINTER" Nut Design allows the use of thin wall-socket wrenches (smaller wrench clearance) compact design . . . It provides increased bearing areas, permitting use with softer surfaces without gouging — precise torquing and hopper feeding are other features. The uniformity of this nut makes practical reproducible torques, from part to part and from batch to batch. "12 POINTER" is made in all comparable dimensions, in all popular sizes of standard nuts, as well as "Huglock" and "Marsden" locknuts . . . Send for twelve-page brochure that supplies complete specifications, engineering data and prices.

NATIONAL MACHINE PRODUCTS COMPANY

Manufacturer of Standard and Special "12 Pointer and Hexagon Nuts..."Huglock" and "Marsden" locknuts,

44255 Utica Rd., UTICA, Michigan

—ITEM 708—

A LOW COST SOLUTION TO ALL AUTOMATIC DESIGN PROBLEMS

CARTER

Power-Pack

AIR CYLINDER AND VALVE

- Only One Air Connection
- Built-in Cartridge Valves
- Integral Speed Controls
- Solenoid or Air Limit Control

Immediate Delivery!

The cylinder-valve combination that is complete! A rugged, dependable cylinder . . . with sensitive, accurate, versatile valving built right in! Ideal for designing into auto-control setups! Close coupled or remote, positive, easy maintenance. Cuts piping costs in half, single, simple pipe connection at valve end only. Check into Power-Pack today!

Every Designer Should Have a Copy of This
NEW BULLETIN

Carter Controls, inc.

2914 Bernice Road, Lansing, Illinois
(Chicago Suburb)
GRanite 4-3305 (Lansing) • BAyport 1-7186 (Chicago)

—ITEM 709—

XUM

ADVERTISING INDEX

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

Mary L. Callahan
Advertising Service Manager

Richard A. Templeton
Research Manager

Pauline J. Herndon
Circulation Manager

David C. Kiefer
Marketing Director

Richard J. Strnad
Production Manager

Amy Lombardo
Directory & List Dept.

District Offices

New York 17 ..... 60 East 42nd St.
Russell H. Smith
James A. Stangarone
Murray Hill 2-2581

Simsbury, Conn. ..... 17 Deerfield Lane
Alan C. Bugbee
Oldfield 8-4764

Cleveland 13 ..... Penton Bldg.
Jack W. Walton
Don J. Billings
Main 1-8260

Detroit 26 ..... 1249 Washington Blvd.
Charles F. Reiner
Woodward 3-3488

Chicago 11 ..... 520 North Michigan Ave.
Howard H. Dreyer Robert Z. Chew
Whitehall 4-1234

Los Angeles 48 ..... 6262 Commodore Sloat Dr.
F. J. Fuller
Webster 1-6865

San Francisco 4 ..... 57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. ..... 331 South Twelfth St.
Fred J. Allen
Griffin 7854

London, S.W.1 ..... 2 Caxton St., Westminster

Published by

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Also Publisher of

STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

Machine Design is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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BPA NBP

Advertising Index

This "STAGGERED" ROLLER DESIGN provides GREATER LOAD CAPACITY for your Heavy Duty Applications

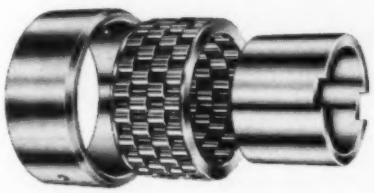
More rollers support the load

200 and 300 SERIES

Separable three-part construction—outer race, roller assembly, inner race. Choice of widths and lengths to suit conditions.

C-200 and C-300 SERIES

Bearings without inner race are denoted by C-200 and C-300 and can be operated on properly hardened and ground shafts.



T-200 and T-300 SERIES

Designed for use on standard commercial cold drawn shafts. Available for slip fit with inner race notched, or for press fit without notches.

COMPARISON OF LOAD DISTRIBUTION

End views of an Orange Staggered Roller Bearing and a conventional bearing show how staggered roller design brings maximum roller surfaces in contact with load. Alignment with raceway load area is maintained, skewing tendencies of long rollers is eliminated, resulting in unusually even, smooth running.

Greater load capacity, plus the wide design latitude of bearing types, permits you to save weight, space and cost by installing Orange Staggered Roller Bearings on heavily loaded, highly stressed applications. On new designs, you often can use smaller sizes . . . on change-overs in present equipment, you add extra margin of safety and smoother running.

Orange Staggered Roller Bearings are available in a full range of sizes, interchangeable with other bearings in these series. Engineering service and stocks in principal centers.

ORANGE

Write for latest Engineering Reference Manual M-55.

ORANGE ROLLER BEARING CO., INC.
556 Main Street, Orange, N. J.

ORANGE "STAGGERED" ROLLER BEARINGS

—ITEM 712—

Look into REVERE Phosphor Bronze – it pays RAVENNA to use it!

This Moen Single Handle Mixing Faucet contains an anchor disc and an anchor washer, both stamped out of Revere Phosphor Bronze Strip. These are small parts, but in a fine product such as this faucet, high quality metals must be used throughout. Here is a condensation of the manufacturer's experience with the phosphor bronze:

Anchor Disc: • Standard punching speed maintained. • No pre-straightening off the arbor for the automatic punching process. • No excessive die wear. • Corners are sharp and clean; no de-burring needed. • Natural mill finish is better than they could achieve by tumbling or burnishing. • High tin content means no lubrication is required; they call it "silent brass."

Anchor Washer: • Have not had a single surface failure. • Dry tumble to de-burr. • Good fatigue characteristics and no obvious signs of corrosion.

Revere offers several types of phosphor bronze, each with slightly different characteristics. In addition to this alloy, Revere also supplies Ravenna with round and octagonal leaded brass tube and free-cutting brass rod, for use in various parts of the valve. We will be glad to collaborate with you on selection of just the right forms of the correct alloys for your products, present or projected. See the nearest Revere Sales Office.

Moen Single Handle Mixing Faucet, made by Moen Valve Co., Division of Ravenna Metal Products Corp., 6518 Ravenna Ave., Seattle 15, Wash.

REVERE

COPPER AND BRASS INCORPORATED

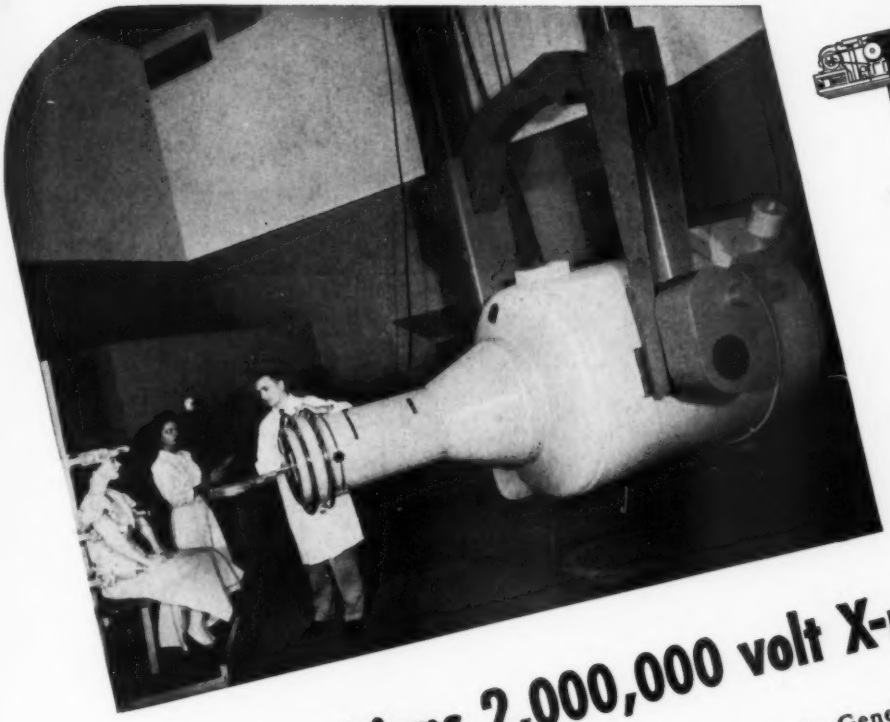
Founded by Paul Revere in 1801

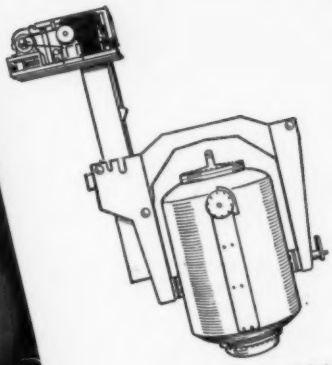
230 Park Avenue, New York 17, N. Y.

• • •

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif., New Bedford, Mass., Newport, Ark.; Rome; N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

"The Revere Four-Way Service" is a 16 mm. sound motion picture in color, educational and informative. If you haven't seen it, write nearest Revere Office.





Close-up of CLEVELAND Series 63F Double Reduction Worm Gear Speed Reducer used to raise and lower this G.E. 2-million volt X-Ray Tube Head.

CLEVELAND positions 2,000,000 volt X-ray machine

QUITE an X-ray machine, this—built by General Electric to serve the New England Deaconess Hospital in Boston, Mass. Quite a job, too, to raise and lower its head—it's heavy, it's delicate, and it has to be positioned accurately. That's why Cleveland was specified to transfer the speed of the motor into slow, smooth and dependable power.

For, with Cleveland worm gear speed reducers, smooth torque flow is assured by virtue of the sliding action of worm on gear. Constant angular velocity assures positive control. Precision matching of case-hardened steel worms to nickel-bronze gears insures 100% dependability.

Experience has demonstrated that a Cleveland actually improves with use. Even when operating under continued severe overloads, danger of sudden failure is remote. Thousands of Clevelands, in fact, operate for the life of driven machines.

Why not get the complete Cleveland story by writing for Catalog 400 today! The Cleveland Worm & Gear Company, 3287 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

—ITEM 552—

For More Information Circle Item Number on Yellow Card—page 19

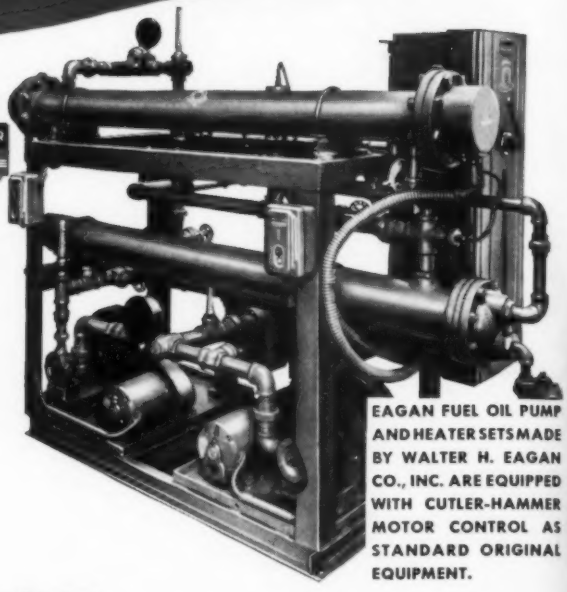
CUTLER-HAMMER

MOTOR CONTROL

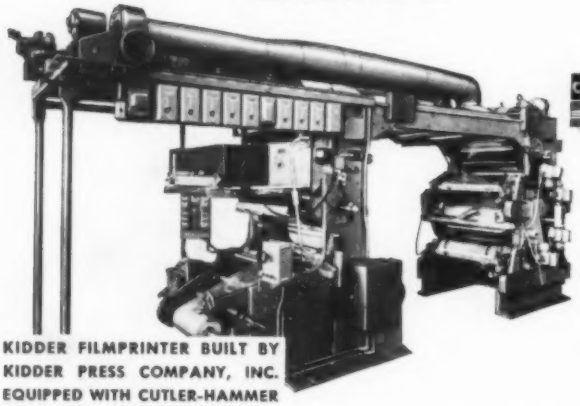
C-H

CHOICE OF THE LEADERS — THE MARK OF BETTER MACHINES

GENERAL TAPER AND LIFT MANUFACTURED BY GENERAL CORRUGATED MACHINERY CO., INC. CUTLER-HAMMER MOTOR CONTROL IS USED AS STANDARD ORIGINAL EQUIPMENT.

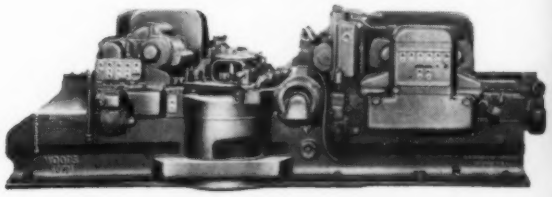


EAGAN FUEL OIL PUMP AND HEATER SETS MADE BY WALTER H. EAGAN CO., INC. ARE EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL AS STANDARD ORIGINAL EQUIPMENT.



KIDDER FILMPRINTER BUILT BY KIDDER PRESS COMPANY, INC. EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL AS STANDARD ORIGINAL EQUIPMENT.

WOODS 409 HEAVY DUTY PLANER & MATCHER BUILT BY S. A. WOODS MACHINE CO. BOTH CUTLER-HAMMER CONTROL COMPONENTS AND HEAVY-DUTY OIL-TIGHT PUSHBUTTONS USED.



The pressure's on!

The pressures on a manufacturer who leads in his market are tremendous. They beset him at every turn. Sales organizations are thrown against his customers. Merchandising and ad campaigns seek to sway. New ideas pour in floods from competing makers. Once off guard, these pressures can uproot him. He has to keep in constant contact with his market. He has to know almost intuitively what direction market needs will jump. He has to keep up a constant product development program. He never relaxes for a moment his control over his manufacturing processes, the raw materials he feeds into them, the finished components he buys to complete his product. Perhaps most sensitive of all is the position of the leading manufacturer whose product is *production machinery*, to be used in other plants. Here a false step can be a major catastrophe.

That such a high percentage of leading machinery builders use and in a growing number of cases *insist* on Cutler-Hammer Motor Control to the exclusion of all others, is a most revealing commentary. It may be the most searching evaluation of all, of the quality and dependability and leadership of Cutler-Hammer Control . . . itself under pressure since its inception more than 60 years ago . . . CUTLER-HAMMER, Inc. 1310 St. Paul Avenue, Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

—ITEM 553—

For More Information Circle Item Number on Yellow Card—page 19